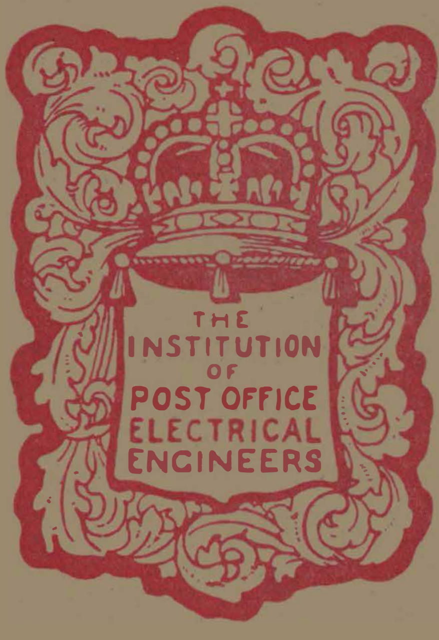
THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



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PART I

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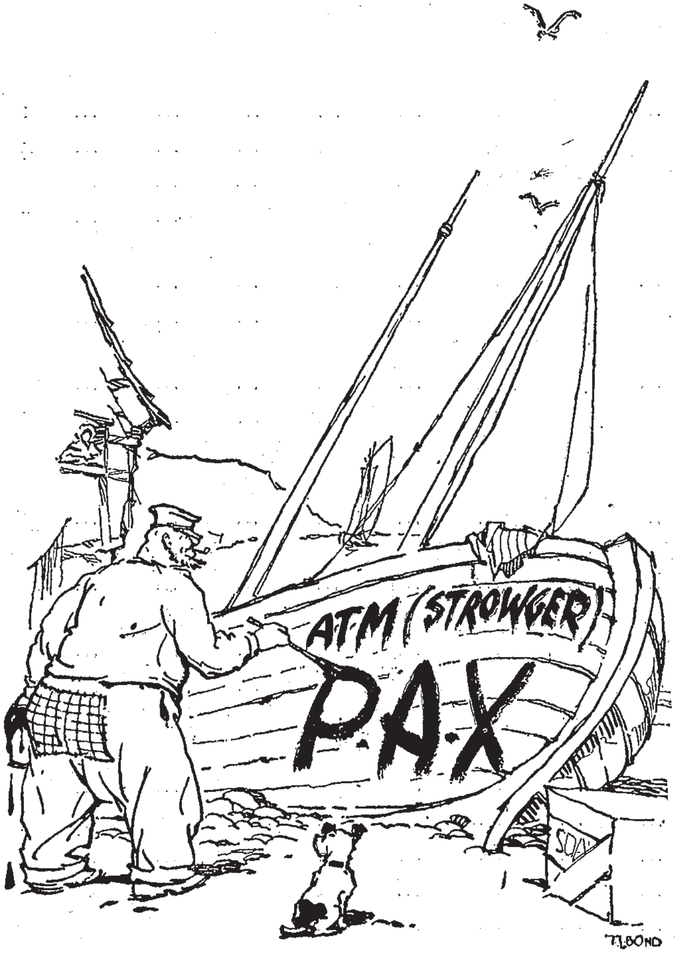

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The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

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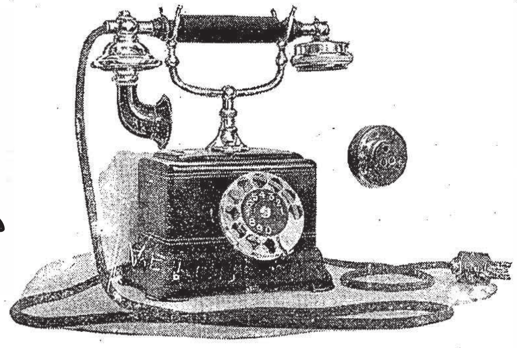

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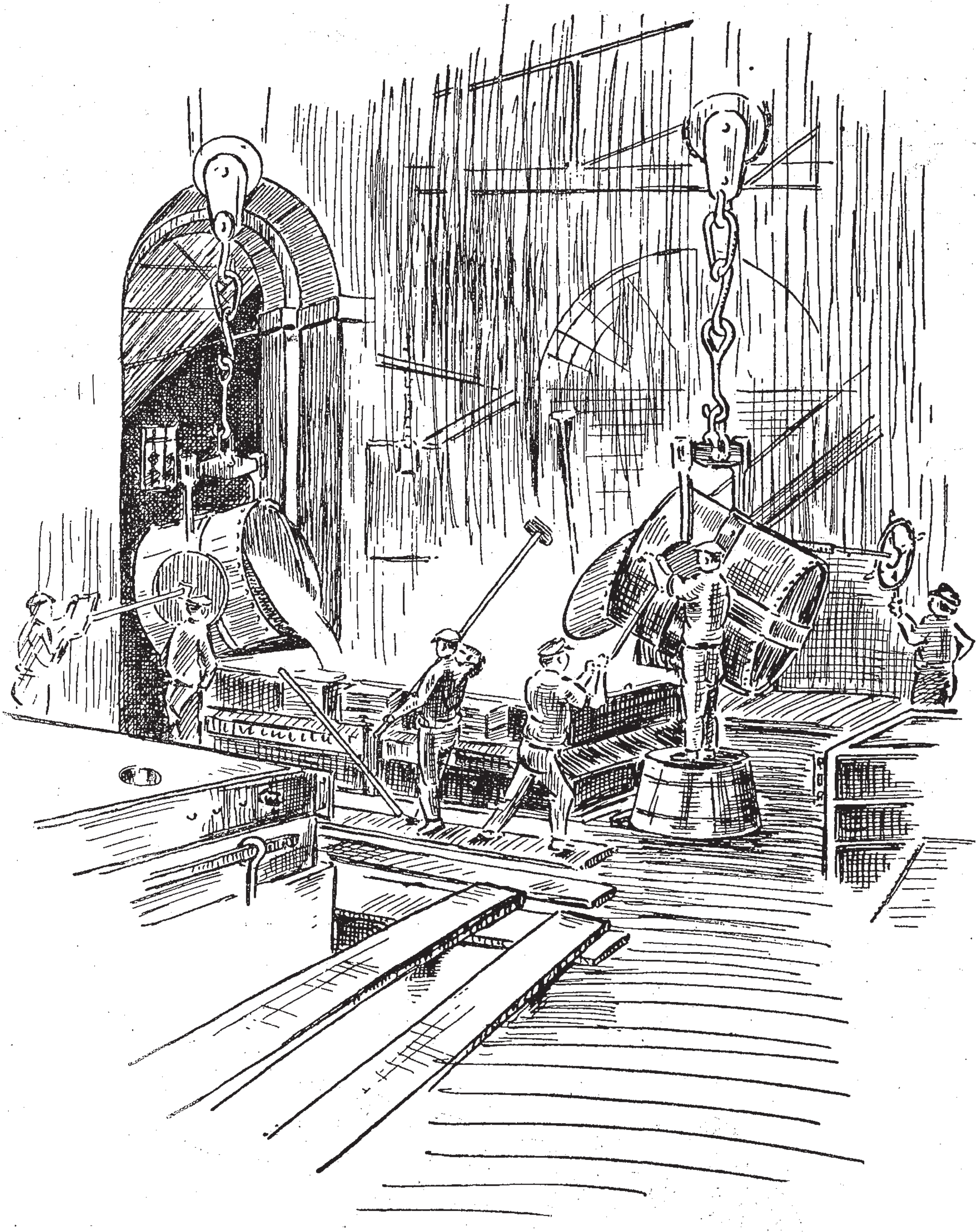

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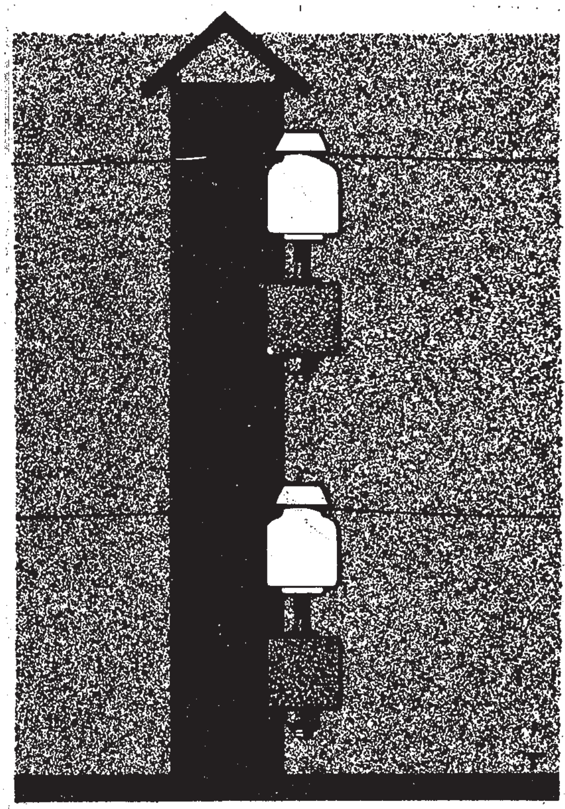

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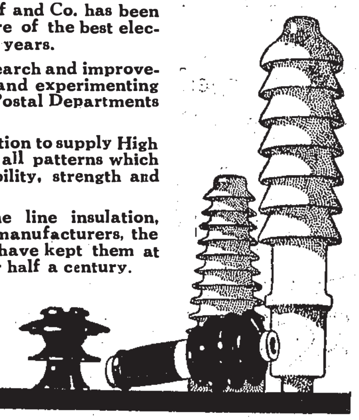

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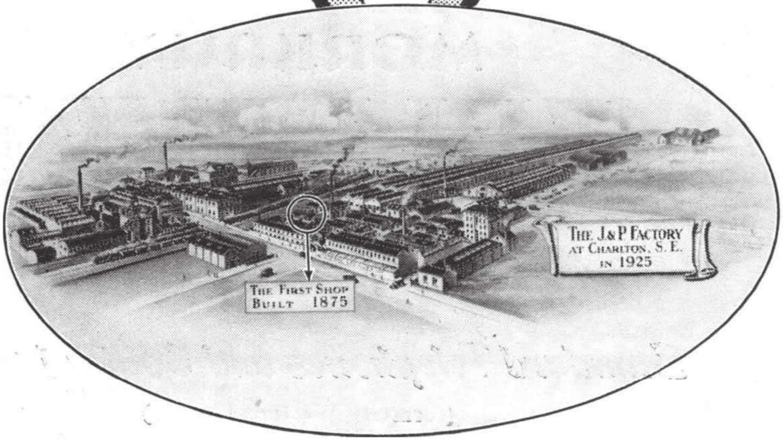
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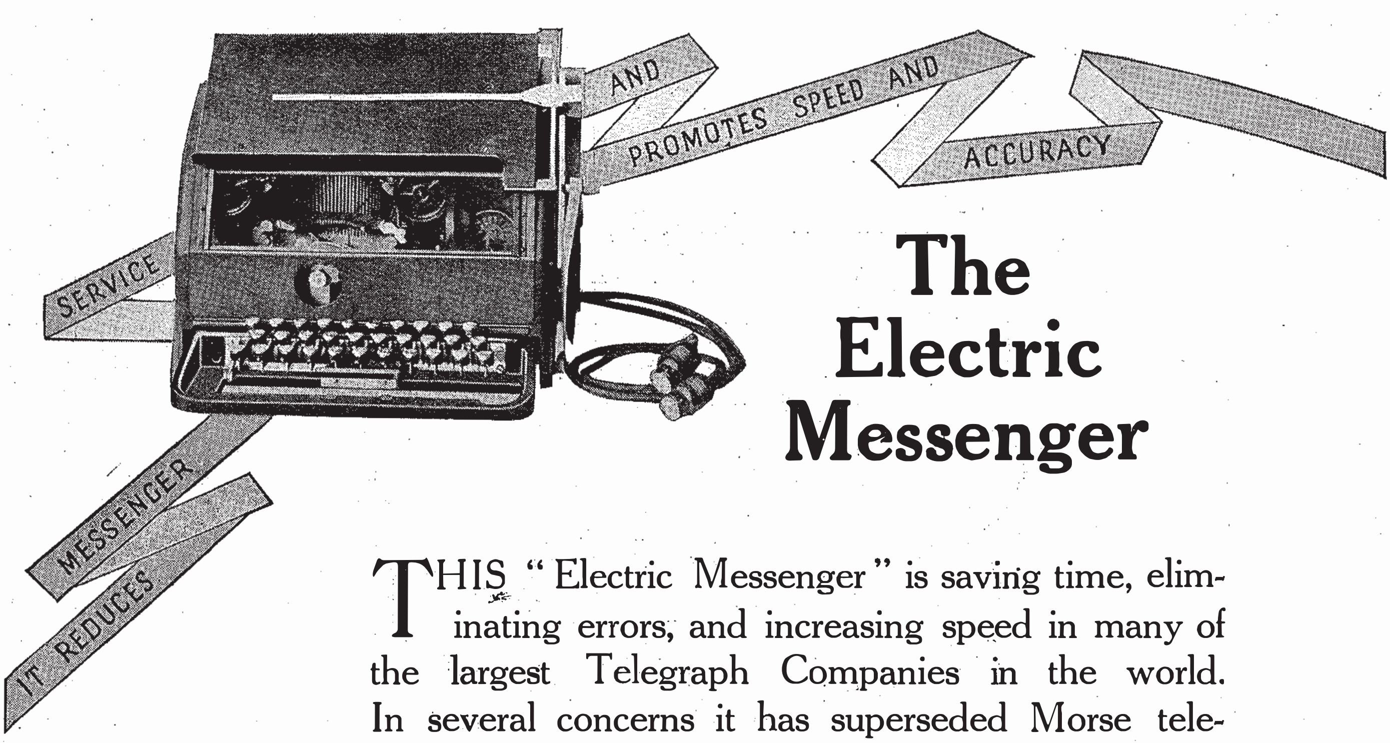

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THE C.C.I. TELEGRAPHS, 1926.

A. C. Booth.

THE International Consultative Committee on Telegraphic Communications, now generally referred to as the C.C.I. Telegraphs, to distinguish it from the somewhat similar body known as C.C.I. Telephones, had its first meeting in Berlin during the first fortnight of November, 1926.

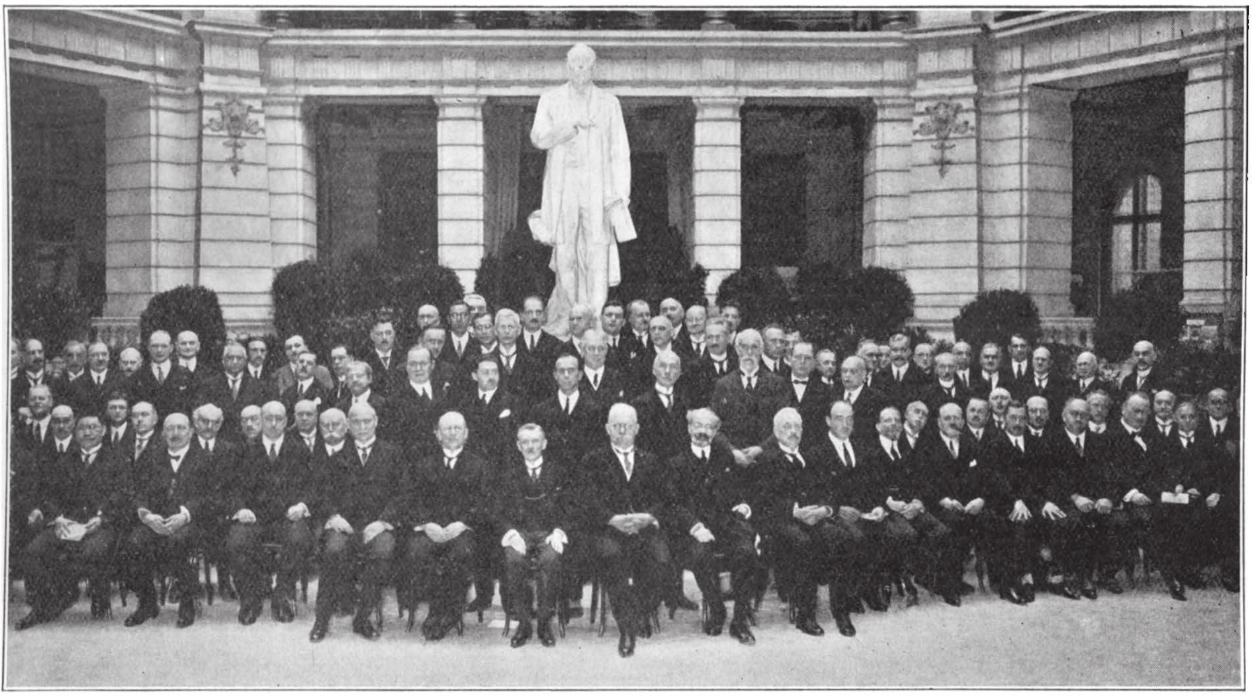


Fig. 1.—Berlin, November, 1926.

The few notes which follow are intended to convey some idea of the extent of this Committee, the matters that were discussed and the progress made.

Delegates were present from most administrations, including China, Japan and Mozambique, also from Cable Companies, Radio Companies and from manufacturers of telegraph apparatus. The absence of representatives from the great telegraph concerns of the United States was noticeable. With the officials of the German Administration who attended the Committee meetings the number totalled to about 100.

The first photograph shows a view of the first meeting in the large hall of the Museum of the German Post and Telegraph Administration, where are housed large models of the most important Post Offices in Germany, samples of most types of telegraph apparatus, uniforms of officials of many years ago, models of old-fashioned mail coaches and even of the modern Zeppelins. The British delegates do not appear in the photograph as they were, with others, placed too far to the left of the position to come within the range of the camera. At this meeting His Excellency Dr. Stingl, the German Minister for Posts and Telegraphs, who is seated in the centre of the front row in the photograph, received the delegates and gave an address of welcome, after which he received the delegates individually. The motor-bus service of the Post Office was used to convey the delegates to the Institute of German Engineers, shown in the second photograph, where all the meetings of the Committee were held.

The Agenda for this meeting was an extensive one, needing considerable preliminary study and discussion. It was as follows :—

A. *Technical.*

1. Characteristics of Telegraph communications.
2. Unification of the fundamental methods of working Telegraph Apparatus.
    - (*a*) Standardisation of working speeds.
    - (*b*) Unification of Telegraph alphabets.
    - (*c*) Construction and working of standard apparatus.
3. Co-existence of Telegraph and Telephone circuits in the same cable.
4. Rules for the construction of aerial lines.
5. Protection of Telegraph lines against the effects of Power circuits.

B. *Traffic arrangements.*

1. Rules for working High-speed and Duplex circuits.
2. Traffic rules, abbreviations, etc.

C. *Organisation of the Committee.*

At the first meeting of the Committee Herr Arendt, Ministerialrat of the Postministerium, Berlin, was unanimously elected President, and sub-committees were formed to expedite the work as much as possible.

Regarding the item A.1, it was decided to recommend the adoption of a new speed unit to be known as the " Baud " in honour of the great telegraphist Emile Baudot.

This unit will be used for all types of apparatus and is easily translated into " words a minutes," " cycles a second " or into other ways of expressing speeds of telegraph working. The Baud is the number in a second of the shortest signal transmitted. For the Morse or Wheatstone system this will be the number of " dots " added to the equivalent spaces transmitted in one second; for the Baudot or similar systems it will be the number of line segments traversed by the Distributor brush in one second. Thus, Wheatstone at a speed of 100 words a minute will be a speed of 80 Bauds, a Baudot Distributor having 22 segments and turning at 180 revolutions per minute will be a speed of 66 Bauds, and a frequency of 20 cycles will be 40 Bauds. This item of the Agenda was not completed and it has been arranged for the Reporters of the various Administrations interested to collect further information for consideration by the next C.C.I. Telegraphs, recommended to take place in the autumn of this year at Como, Italy.

Regarding A.2, with its sub-sections, there was not sufficient time to deal with (*a*) and (*c*) and even (*b*) was not completed, although considerable progress was made with a difficult and highly contentious subject. The international signal for " Full-stop " in Morse is still the three letters " I, I, I," which is not suitable for use with the Creed Printing Telegraph system. It was therefore unanimously agreed to recommend a change to that already in use in this country, viz., " dot dash dot dash dot dash." The " Comma " signal is in use to some extent on the Continent and it was agreed to recommend the use of the Exclamation signal, " dash dash dot dot dash dash," for this purpose, whilst abandoning entirely the use of an Exclamation character.

With regard to the Hughes instrument, which is being rapidly displaced by more useful systems, it was recommended that no changes should be made on account of the cost and inconvenience that would result for a possible very small improvement in working.

The 5-unit code was productive of a great deal of comment and on account of the very large extension of its use throughout the world during the last few years it is the one that requires urgent settlement. In this country there are already five 5-unit codes in use, viz.:—

1. Baudot, Foreign.
2. Baudot, Inland.
3. Murray, with two space keys.
4. Western Electric, with one space key.
5. Siemens.

Suggestions were made to provide yet another 5-unit code to displace all of the foregoing, also for a 6-unit code, but it was finally agreed to consider a modification of the Baudot code to make it suitable for modern requirements with the minimum possible alteration.

FIG. 2.—HAUS DES VEREINES DEUTSCHER INGENIEURE IN BERLIN.

Naturally the French and Belgian Administrations, with the very large number of trained Baudot operators and their numerous Baudot circuits, would suffer very great inconvenience and expense in making any changes that may be considered desirable. As the proposal is to apply only to new circuits the disadvantage is not so great to commence with and will automatically grow less as time goes on. The uniformity thus obtained will, in a matter of a few years, amply repay for the cost and inconvenience that will arise for a short period in varying degrees to all administrations concerned. The matter was not concluded and is to be further considered at the next meeting.

With regard to A.3, this matter has to be considered in conjunction with the recommendations of the C.C.I. Telephones, who are more concerned than the C.C.I. Telegraphs, from the point of view that telephone circuits do not interfere with telegraph circuits, while the latter are liable to prejudice very seriously the good working of telephone circuits if certain technical requirements are not fulfilled.

Representatives of both C.C.I. Telegraphs and C.C.I. Telephones are to continue with this matter for the next meeting, on the basis that both systems are to work in the same cable. Consideration is also to be given to the allocation of the bands of frequencies for carrier currents.

The item A.4, dealing with the continuous insulation of land lines, brought forth several opinions strongly in favour of this procedure for circuits which were affected by climatic conditions, and the discussion will be continued.

The item A.5, dealing with the protection of telegraph lines from the effect of power circuits, was not finished, but it was agreed that the conditions should closely follow the requirements on the same subject already under the consideration of the C.C.I. Telephones, with suitable additions or alterations to allow for the different conditions of Telegraph circuits.

The item B.1, for working High-speed and Duplex circuits, was thoroughly discussed and the resulting rules to be recommended follow very closely those made for use in this country prior to 1906 and embodied in the Post Office Technical Instruction on the Hughes Printing Telegraph system, as the result of years of experience of this method of working. They remain equally effective to-day and it will be an all-round advantage for all Administrations to have similar rules.

Numbering of telegrams, instead of sending them in batches of ten or less, is recommended and various methods have been put down for trial by the Administrations and Cable Co.'s willing to make trials on the different classes of telegrams.

The item B.2, dealing with Traffic rules, abbreviations, etc., is to be studied further and reported on at the next meeting.

The item C.1, on the Organisation of the

Committee, dealt with expenditure and procedure as well as the arrangements for the next meeting. It was decided that the Italian Administration should be asked to undertake the work and provide for a meeting in the autumn of 1927. The German Administration would continue with the correspondence for about six months and then hand over all matters to the Secretary of the new Committee, which would hold its meetings at Como.

[*It has just recently been decided to postpone the next meeting until the spring of* 1928, *on account of the International meeting on Radio matters to be held at Washington in the autumn of this year.*]

SPEEDS OF WHEATSTONE TELEGRAPH TRANSMITTERS.

A. C. Booth.

ALL those who are acquainted with the Wheatstone method of working are well aware that the speed of the instrument is generally measured by passing through it a perforated tape ten feet long and then dividing 3,000 by the number of seconds occupied by the tape in passing through. The result obtained is the "speed in words a minute."

Another and simpler way for moderate speeds is to count the number of revolutions of the guide-wheel under which the perforated tape passes. This wheel has 20 teeth and will therefore in one revolution pass through 20 complete reversals, or five-sixths of a word. Therefore the number of revolutions of this wheel in 50 seconds is the speed in "words a minute" on the Wheatstone basis of calculation. It is of course more convenient to take the number of revolutions in 25 seconds and double it. The wheel can be conveniently marked on its side, or a file-cut made in its rim for the convenience of counting revolutions by very lightly touching the rim with the finger.

If the wheel had 24 teeth, one revolution would have been equal to one word, and counts could then have been made for 10, 15, 20 or more seconds, depending on the accuracy required. Arrangements have been made to alter this wheel to 24 teeth for some new instruments, and perhaps later on the older ones will also be altered as they come in for repair if the additional convenience justifies the extra cost, which, however, is not great.

THE MEASUREMENT OF TELEGRAPH SPEEDS.

THE Wheatstone System:—In this system a perforated paper tape with the Morse signals is passed through the transmitter. The fundamental unit of measurement is the distance between centre holes, of which there are ten per inch, or one hundred and twenty per foot. In the punched tape a dot and its space signal are formed whilst the tape between two centre holes passes through the transmitter; the dot is therefore one-twentieth of an inch long, as also is a space. A dash and its space take up three-twentieths and one-twentieth of an inch respectively, whilst a letter space takes up the space of the previous signal plus one-tenth of an inch, or three-twentieths of an inch. In considering the number of reversals, a dot and its space may be considered a complete cycle at the fundamental frequency in terms of sine waves, it being understood that for well-shaped signals certain harmonics are also present. One cycle therefore corresponds to one-tenth of an inch.

It is stated in the Telegraph Diagram Book that five average words go to a foot of tape, so that one average word is 120 divided by 5, or 24 centre holes long.

For example, 90 words per minute correspond to 90 × 24 or 2160 centre holes per minute or 36 per second; 90 W.P.M. therefore correspond to a fundamental frequency of 36 cycles per second.

Measurement of speed with stop watch:—

The author's stop watch has an outer scale for timing speeds taken over a quarter of a mile distance reading in miles per hour, which he uses in the following manner:—Three feet of slip are measured off on the base of a Wheatstone receiver; this length will contain fifteen average words and is timed by the stop watch, the speed in miles per hour corresponding to the number of words per minute. This will be seen best if, for example, the slip took exactly 15 seconds; the watch would read 60 miles per hour, since a quarter mile in 15 seconds is a mile in one minute or 60 miles an hour, and 15 words in 15 seconds is 60 words in one minute. For speeds over 60 W.P.M. it is found more accurate to take the time of 6 feet of slip and double the reading in miles per hour to give words per minute.

Baudot System:—In this system, taking the Quadruple Duplex as an example, a brush passes over 22 segments 180 times a minute or 3 times a second. Twenty segments are used for 4 letter signals and 2 for correction of speed. Each letter consists of combinations of 5 signals, there being no spacing interval. In order to get the fundamental reversing frequency, consider alternate arms sending the letter "T" and the letter "G." This will make alternate segments positive and negative, hence the cycle will correspond to two segments or one revolution to 11 cycles, and therefore when running at 180 revolutions per minute or three per second the equivalent fundamental frequency will be 33 cycles per second.

If the average word has five letters, in the Baudot system this will require an extra signal for the space between the words or six signals per word or six revolutions per word for each channel; one word, therefore, takes 2 seconds or each channel will give 30 words per minute or four channels 120 words per minute and if duplexed this number of words in each direction.

Comparison of Baudot and Wheatstone:—Quadruple Baudot corresponds to 33 cycles per second for 120 words per minute. What is the Wheatstone speed corresponding to 33 cycles per second? From what has been said before, it will be seen that the number of words per minute multiplied by 4 and divided by 10 will give cycles per second (since 24 cycles go to a word and 60 seconds to a minute). Conversely cycles per second multiplied by 10 and divided by 4 will give words per minute. Hence 33 cycles per second correspond to $82\frac{1}{2}$ words per minute; from this it will be gathered that apparently in this respect the Baudot system is superior to the Wheatstone system.

E.S.R.

A KEYBOARD PERFORATOR FOR BAUDOT CIRCUITS.

A. C. Booth.

With the rapid extension of the use of the typewriter for writing purposes and the development of machine telegraphy in the place of the direct hand-signalling method of the Morse key, or the stick-perforator of the Wheatstone system, it was inevitable that the typewriter machine would soon be adapted to the telegraph system, which after all is only a means for "writing at a distance," and should therefore be done by a typewriter capable of being worked at a distance. That has, in fact, been the development during recent years and has necessitated very important departures in many of the main features of the older telegraph systems. These departures were rather serious handicaps to the introduction of the newer systems and it was therefore desirable, if at al practicable, to introduce a machine with th typewriter form of operation which would b suitable for actuating receiving apparatu already in use, provided of course that thi very great advantage was not outweighed b other serious disadvantages.

The first telegraph keyboard perforator date well back into last century, before the arrangement or lay-out of the keys had been standardised to the extent that has now been attained.

As far as the British Post Office, Inland Telegraph service, is concerned, a standard lay-ou of the keys on keyboard perforators and o telegraph typewriters has been adopted. Th chief feature of this arrangement is that ther are only three rows of keys for characters, with two combined space and change levers situated in front to allow for the use of one or other of the two characters assigned to each of the other thirty keys. This arrangement is eminently suitable for the use of the 5-unit code of Murray, Siemens, or of others of the kind, but was not applicable to the Baudot code of the 1870 period, which had the secondary characters allocated differently to that of the standard keyboard layout.

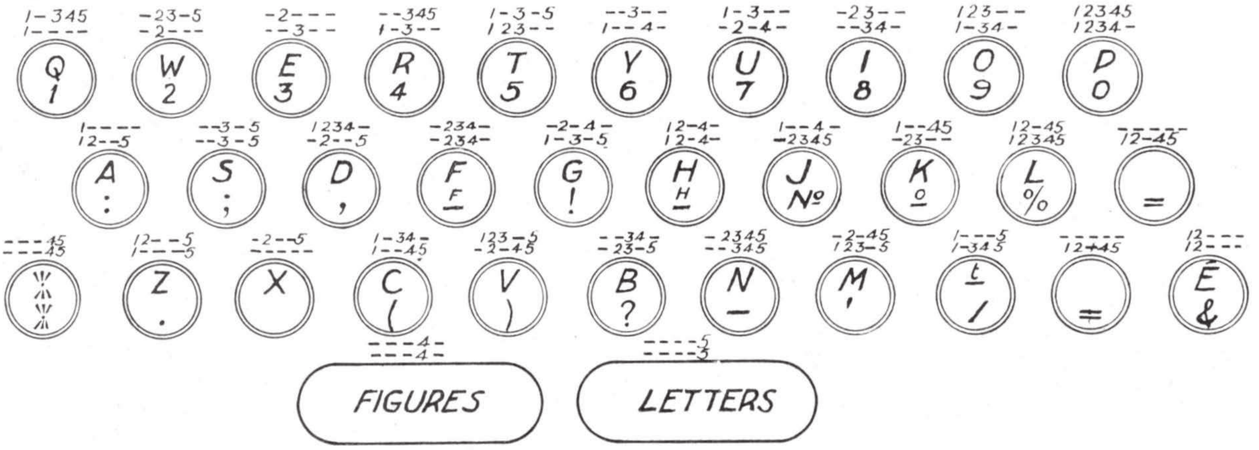


Fig. 1.—Baudot Keyboard for Foreign Circuits.

The perforator about to be described is fitted with a device that enables the use of the Baudot code to be made without any alteration to the receiving apparatus when constructed to be actuated with the Baudot code. This means that each key must be able to effect two entirely different selections so as to perforate two entirely different sets of holes in the perforated tape, depending on which of the control keys marked "Letters" and "Figures" has been used.

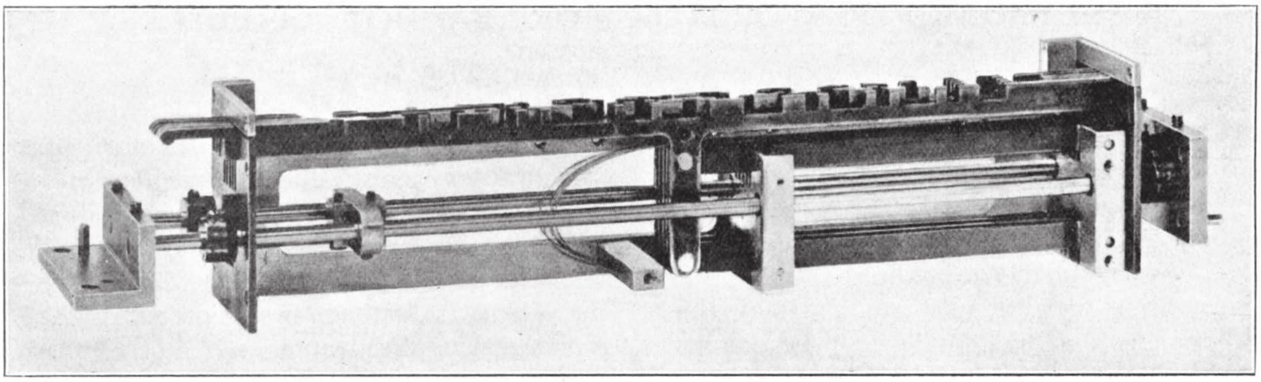


Fig. 2.—Code Bar Carriage. Front Plate Removed.

After the "Letter" key has been depressed, the back row of keys will perforate holes corresponding to the Baudot code Q W E R T Y U I O P, but after the "Figure" key has been depressed these same keys produce figures in the correct numerical order in the Baudot code and have different perforations from the corresponding letters.

Fig. **1** shows the arrangement of the keys for the Baudot keyboard perforator used on the Anglo-Continental services, with the perforations for the two positions shown in small figures just above each key.

Beneath the key levers is an aluminium frame or carriage capable of sliding on two substantial rods to take up either of two positions according to the particular space key which has been depressed. This frame (Fig. **2**) contains the five code-bars which, when depressed, actuate one or more of the five selecting levers. The code-bars are slotted in such fashion that in one position of the carriage, any one key will depress certain of the bars to produce a corresponding Baudot letter, whilst in the second position of the carriage the depression of the same key-lever will act on a different set of the five code-bars.

As there is a possibility of an operator accidentally depressing two keys at once, arrangements were made to reverse the usual operation of selecting the required punches by arranging for the keys to select those that were not required, thus leaving in position for action by the punch-hammer those punches that are required. Hence a depression of any two keys will withdraw out of action more punches than necessary. The operator can then back-space the tape one letter and actuate the correct key. This is a very important economical advantage from the operating point of view as it avoids an erasure, repunching and the transmission of the unwanted signals over the line.

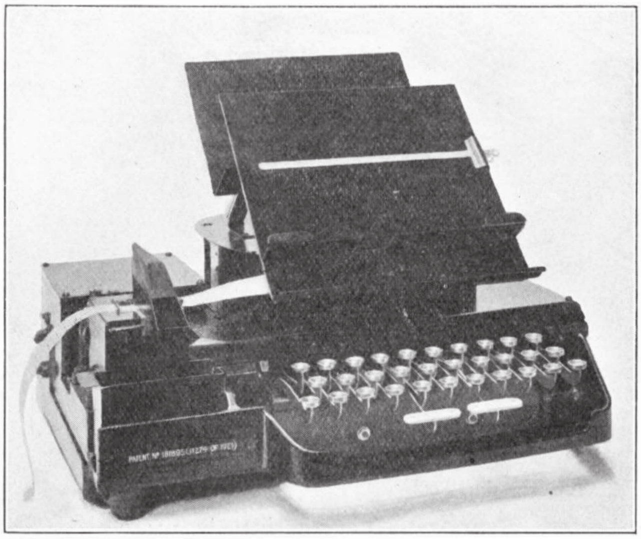


FIG. 3.—GENERAL VIEW OF INSTRUMENT.

Fig. 3 shows a general view of the instrument, with the second desk or rack for accommodating the messages that have already been dealt with. In a later form this second desk has been made of double width for accommodating in the second part those messages awaiting correction, etc. Rubber covers have been fitted over the two space levers to lessen the possibility of fatigue to the thumbs, which does sometimes occur.

As this perforator is required to actuate tape-printers only, no lamp is required for indicating the end of the line.

Code-bars.—These are slotted differently for each of the five, and are therefore not interchangeable. Key-levers when depressed pass either into the slots and do not actuate the code-bars, or if a slot is not under the key the code-bar is depressed to actuate the selecting lever and to withdraw the corresponding anvil, thus preventing a perforation being made.

Punch-magnet.—Every key lever acts on another common lever which closes the contact of the punch-magnet circuit. The hammer of the magnet acts against any of the five anvils that may be in position, causing corresponding punches to perforate the tape. The return of the armature causes the paper tape to be fed forward one-tenth of an inch ready for the next set of perforations. The punch-hammer also acts every time on a narrower and longer punch which perforates the feed-holes of the tape.

Fig. 4 shows a skeleton of the machine with one key depressed. In its movement it has depressed the front code-bar but not the other four, where slots were beneath it. The front code-bar has actuated the front selecting lever, which has withdrawn the anvil " D " from the path of the punch-hammer " E "; consequently there will be four perforations made corresponding to the Baudot code letter " L " and the progression hole. The punch-magnet circuit is closed by the depression of the frame " G," at the contact " H."

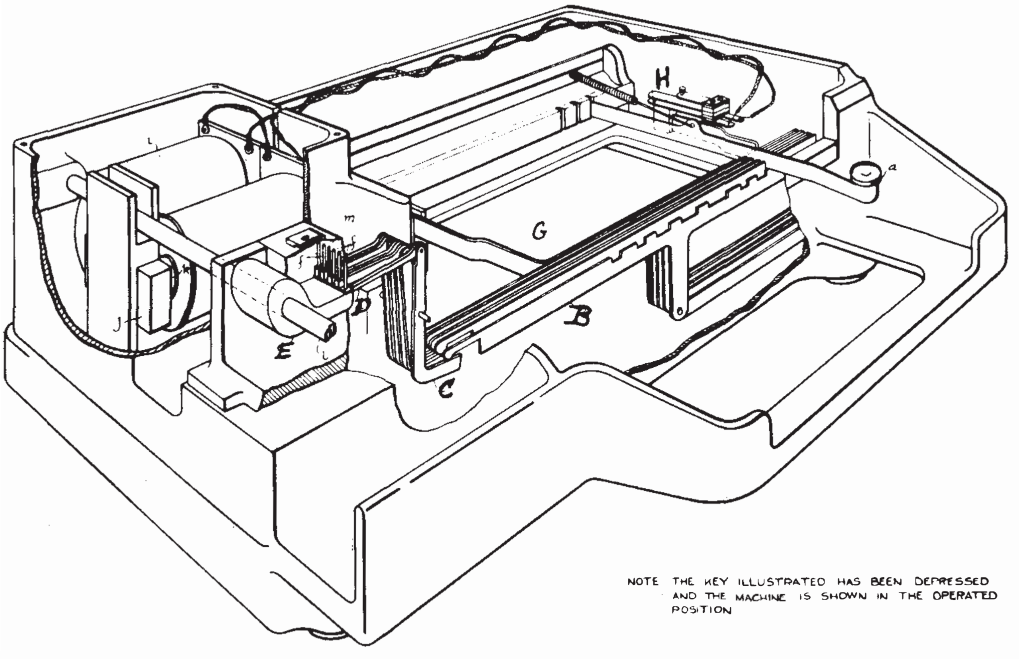
When the key is released the contact-bar and code-bars are restored by their respective springs ready for the next depression of a key; the contact is opened and the armature moves away from the electro-magnet.

The Shift device.—The two space keys which also shift the carriage are each fitted with an extension piece for actuating two bell-crank levers mounted on the framework. These in turn act on two pins fitted on the movable carriage, causing it to shift a distance of one-eighth of an inch. In either position the carriage is locked by a jockey-roller, which bears on the lower edge of the left-hand end plate. To ease the movement of the carriage its weight is supported by a spiral spring on the right and by the spring of the jockey-roller on the left.

The Punch-block is situated on the left side of the instrument and carries the die-block, the punch-hammer in its bearings, the back-space key and the guide-plate for the selecting levers.

The Die-block carries the punches, the die-plate, the feed-wheel spindle and the paper guides. The punches move in guide holes and are withdrawn from the path of the paper tape by straight wires of spring steel. The distance through which the punches are moved is regulated by adjusting the height of the stop-plate of the punch-hammer, which latter can be adjusted angularly in relation to the armature shaft at the coupling with the hammer shaft.

The Paper-feed mechanism.—A pawl mounted on an extension piece of the punch-hammer steps the ratchet wheel forward one tooth on the return stroke of the punch-hammer. On the same spindle as the ratchet-wheel is a seven-pointed star-wheel which engages with the progression holes in the paper tape and feeds it forward one space for each return stroke of the punch-hammer. The correct position of the paper tape is obtained by a jockey roller which by a spring engages with the spaces between the teeth of the ratchet wheel and is adjustable by means of two screws at the back of the die-block.



NOTE THE KEY ILLUSTRATED HAS BEEN DEPRESSED AND THE MACHINE IS SHOWN IN THE OPERATED POSITION

FIG. 4.—SKELETON OF MACHINE. ONE KEY DEPRESSED.

The Back-spacer.—This is a key mounted in the punch-block for stepping back the paper tape for correcting a punching error. It releases the feeding pawl and brings in a reversing pawl which steps back the paper tape one progression hole for each depression of the back-spacing lever.

The Electrical Circuit.—The two coils of the electro-magnet are each of 60 ohms resistance, connected on one side to a resistance coil of 60 ohms and on the other to the contact-maker, which is shunted by a condenser of one micro-farad connected in series with a resistance coil of 60 ohms to quench the spark resulting from the cessation of the current in the electro magnet. An earth connection is made to the frame of the instrument to avoid the possibility of shocks to operators if a fault should occur to the electrical circuit. The voltage required to operate the punch magnet is normally 110, but may be between 105 and 115.

The instrument weighs 46 lbs., is 17 inches long, 12 inches wide and $11\frac{1}{2}$ inches high.

With this machine and its automatic transmitter a Baudot circuit may have its speed increased from 180 revolutions a minute to 210, 240 or even higher.

The machine has been worked at 80 words or 480 depressions a minute.

TANDEM AND HOLBORN AUTOMATIC EXCHANGE POWER PLANT.

P. B. Frost, B.Sc. (Eng.), A.M.I.E.E.

THE Power Plant at Tandem and Holborn Exchange presents a number of points of interest not only because it differs considerably from that provided for exchange work hitherto, but because it is the first installation of power plant for an automatic exchange of the Director type.

Capacity of Plant.—In the absence of any practical experience of Director and Mechanical Tandem working it was difficult to make a close estimate of the capacity of the plant which would be required. Not only was the available traffic data of an approximate character, but many of the circuits had not reached finality, and therefore the consumption of power for the various automatic operations was more or less indeterminate.

The limitations imposed by floor space for the batteries and a desire not to experiment with cells of a capacity much in excess of what had been used in the past, either in telephone exchanges or by supply authorities, led to the selection of a capacity of 10,000 ampere-hours, at the nine-hour discharge rate, as the maximum size which could be conveniently accommodated and maintained.

As the peak loads were expected to reach 2500 amperes at Tandem and 1500 amperes at Holborn it was considered desirable to provide a means of paralleling the exchange loads and their discharging batteries, in emergency, so that with the lower average discharge rate the supply could be maintained to the exchanges for a longer period.

Under normal conditions, with the discharge rates named above, it would not be possible to discharge the battery below 1.87 volts per cell without allowing the P.D. at the Distribution Fuse Board to fall below 46 volts, the agreed minimum necessary for the proper operation of the switches. There should, however, be no difficulty in preventing a nearly discharged battery from being called upon to supply the peak load of the exchange.

Design of Generators.—It was considered necessary to provide a type of charging generator which could carry part of the load during busy hours, and with this in view experiments were made upon large commercial type generators serving an exchange with a floating battery to ascertain whether the voltage rise necessary to enable a generator to relieve the battery of half or three-quarters of the exchange load would be within the safe limit for a director exchange, and also to confirm that a sufficiently quiet service could be obtained under such conditions without using special telephone type generators. The conclusion reached was that floating could be resorted to and that semi-telephone type generators would be satisfactory, there being no need to incur the disadvantages of metal brushes or smooth core armatures. The four charging sets, shewn in Figs. **1** and **2**, have an output of 1600 amperes at 57 volts each, with voltage regulation between 50 and 68. The generators are 12-pole, shunt-wound, non-interpole machines, with special features, such as high-tooth frequency, semi-closed staggered slots, an air gap tapering from 3/16″ under the leading pole tip to 3/8″ under the trailing pole-tip (to check distortion and ensure greater uniformity of flux density in the teeth) and wide brushes of a graphite-carbon combination.

The motors to which these generators are direct-coupled run at 600 r.p.m., and are ordinary 200-volt, 8-pole, shunt-wound interpole machines with no special features, except a tapered air-gap as described above.

The sets have an overall efficiency of 82% at full load and 78.5% at half load.

They are controlled by the starting pillars seen in Figs. **1** and **2**. The latter are completely enclosed by glass doors interlocked with the isolating switch and are practically foolproof. The main circuit is made and broken by an electro-magnetically operated D.P. contactor, all the automatic protective trips and hand trips being arranged to interrupt its holding circuit. A diagram of connections (Fig. **7**) and a description are given later in this article.

Power Supply. Duplicate sources of supply are obtained from the low voltage mains of two different companies. The motor-generator sets constitute a heavy additional load upon the existing mains and the companies have been very doubtful as to whether they have sufficient capacity to carry it. Each company finally agreed to take the load of at least one set, but it is recognised that it may be necessary to discontinue charging while floating is resorted to, or even to charge at night. This point can only be decided when the extent to which floating is necessary is known.

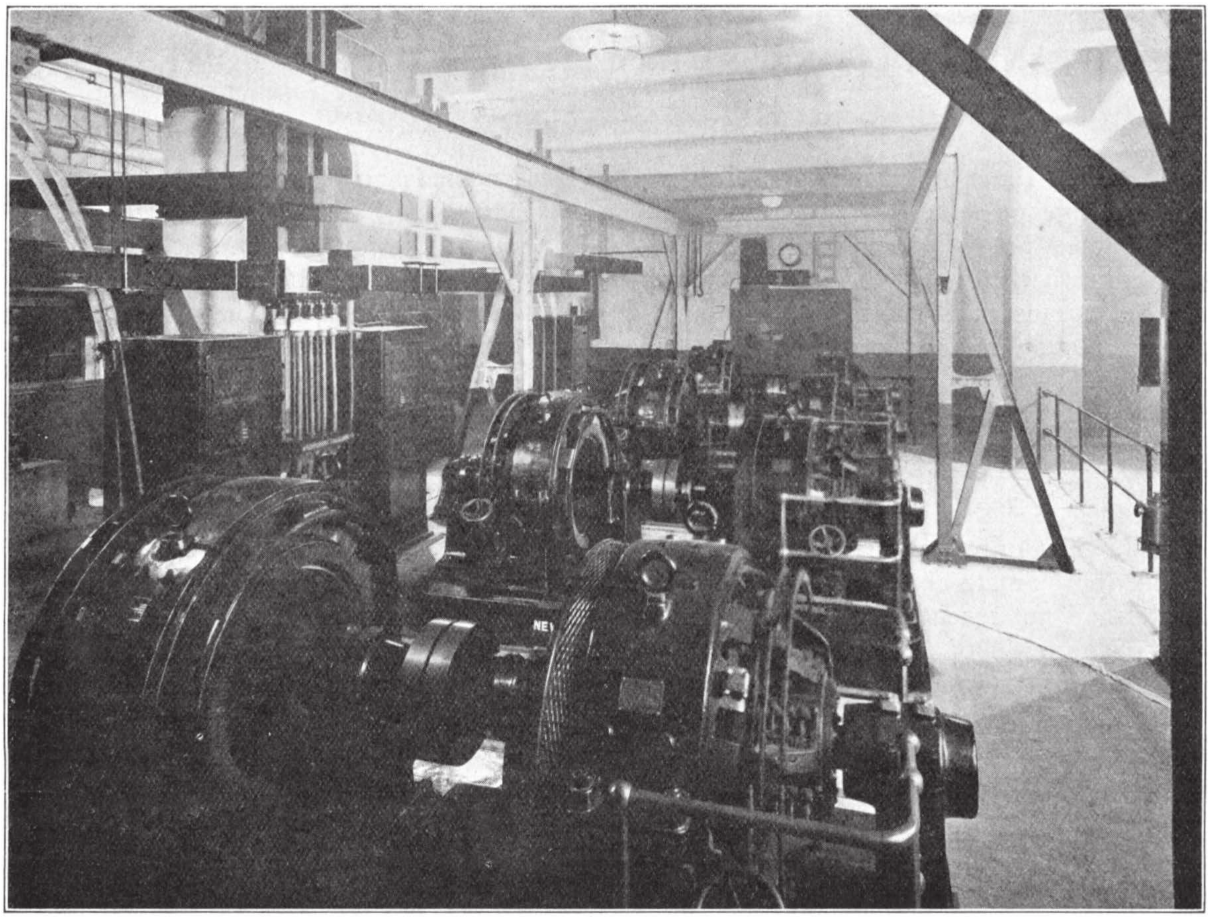


FIG. **1**.—POWER ROOM; TANDEM AND HOLBORN EXCHANGES.

The situation has been somewhat relieved by the introduction of an additional high-tension service and step-down transformer to take the lighting, heating and general power load other than battery charging. An earlier proposal by the supply company to instal a rotary sub-station on the premises had to be abandoned for lack of space.

Crane.—An overhead hand operated travelling crane has been provided to facilitate erection and subsequent dismantling of the sets for repairs. It provides movement in both directions over the space occupied by the four charging sets. It will lift 25 hundredweight, which is the heaviest single part of these machines. The steelwork supporting the crane stands out prominently in Fig. **2** and the crane is just visible in Fig. **1** at the far end of the room.

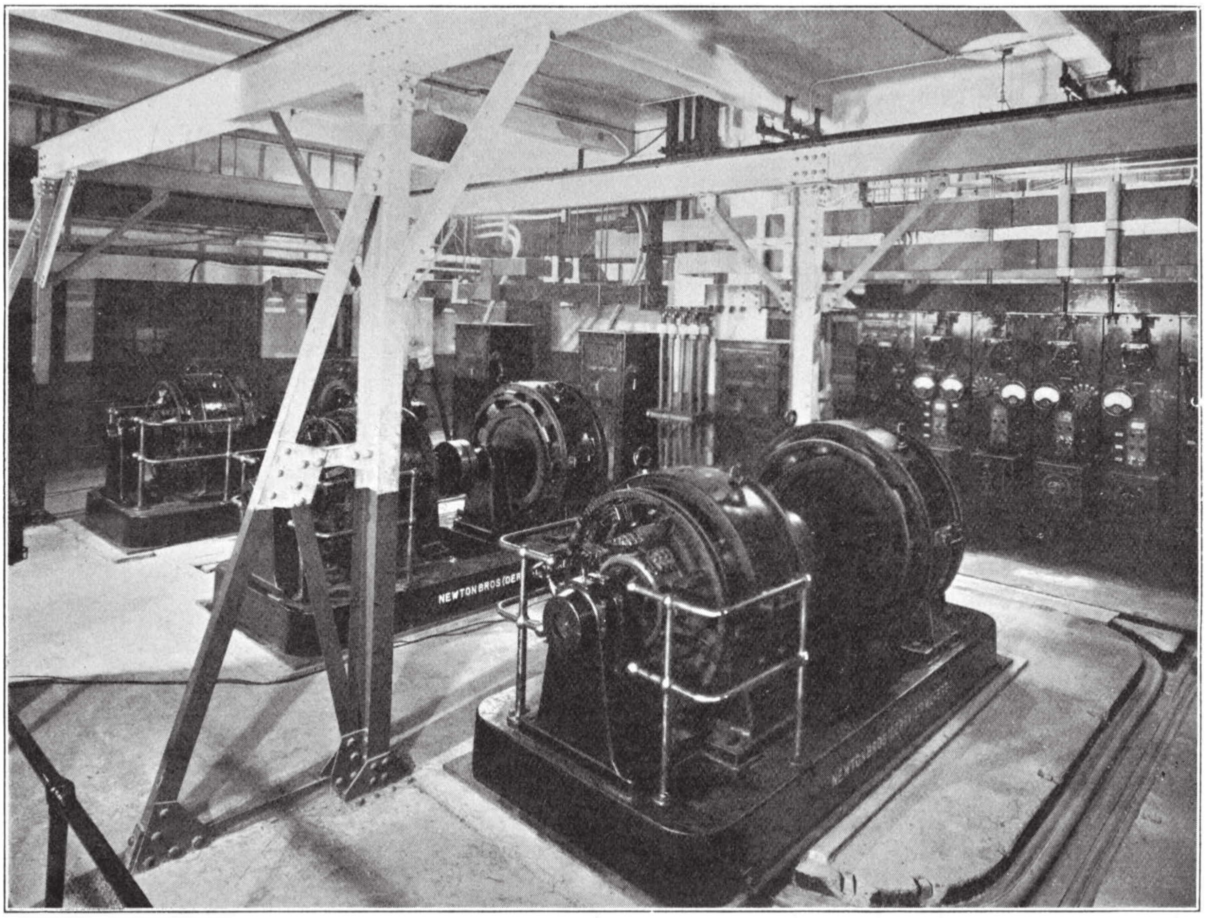


Fig. 2.—Power Room, Tandem and Holborn Exchanges.

Batteries.—Two 25-cell batteries have been provided for Tandem and two for Holborn. Each battery has a capacity of 9870 ampere-hours at the nine-hour rate. The wood lead-lined boxes are spaced at 1′-10½″ centres and are 5′-8″ long. The overall height of the cells is 5′-0″, whereas the minimum clear height of one of the rooms is only 8′-6″. Each cell contains 71 plates, 14″ × 29″, and weighs over 2 tons when fully equipped.

A view of the Tandem battery room is given in Fig. **5**, and views of the Holborn battery room in Figs. **4** and **6**.

A new feature is the method of supporting the cells, each of which rests upon 8 oil insulators standing upon 8 pedestal insulators of hollow stoneware 10″ high, the latter being prevented from sinking into the asphalte floor by large thick tiles. It will be noticed that this type of insulator dispenses with the need for wood stillage and permits a hose to be used for cleaning the floor.

Battery Circuit Breakers.—For the protection of the batteries overload circuit breakers with a special time lag attachment have replaced the usual fuses, because the latter give rise to a much higher voltage drop and in such large sizes are unreliable. The circuit breakers are mounted upon a heavy iron frame which is enclosed by uralite boards. They are operated from outside the battery room through a sliding window, which will normally be locked. This arrangement protects the circuit breakers from corrosion and unreliable operation, and from being accidentally tripped. It also removes the risk of explosion in a low-pitched room in which artificial ventilation by a duct and fan has necessarily been provided.

Main Connections (partly visible in Figs. **1**, **2**, **3**, **4**, **5** and **6**).—The considerable length of the discharge circuit, together with the voltage limits of 46 to 52 at the main Distribution Fuse Board busbars, which must be maintained under all conditions of load, have necessitated very careful design of the main connections. Economy led to the adoption of hard-drawn copper bars, supported upon porcelain insulators carried by iron hangers from the ceiling.

The supports were made rigid to withstand the great forces which would result from a short-circuit current that could easily attain 50,000 amperes, and the diagonal ties at right-angled bends are to check the tendency of the conductor to straighten itself under such conditions. The force between two conductors six inches apart would be in the neighbourhood of 200 lbs. per foot run with a short-circuit such as that referred to.

The positive conductors from all four machines and batteries are brought to the foot of a main column of the building and there commoned. The negative conductors from the battery circuit breakers are run to this point after passing through switchgear upon the power board. From the foot of this column the two main feeds to the two exchanges upon upper floors are formed of copper bars clamped to the column and rising vertically through large holes in the floors to the busbars of the main D.F. Boards.

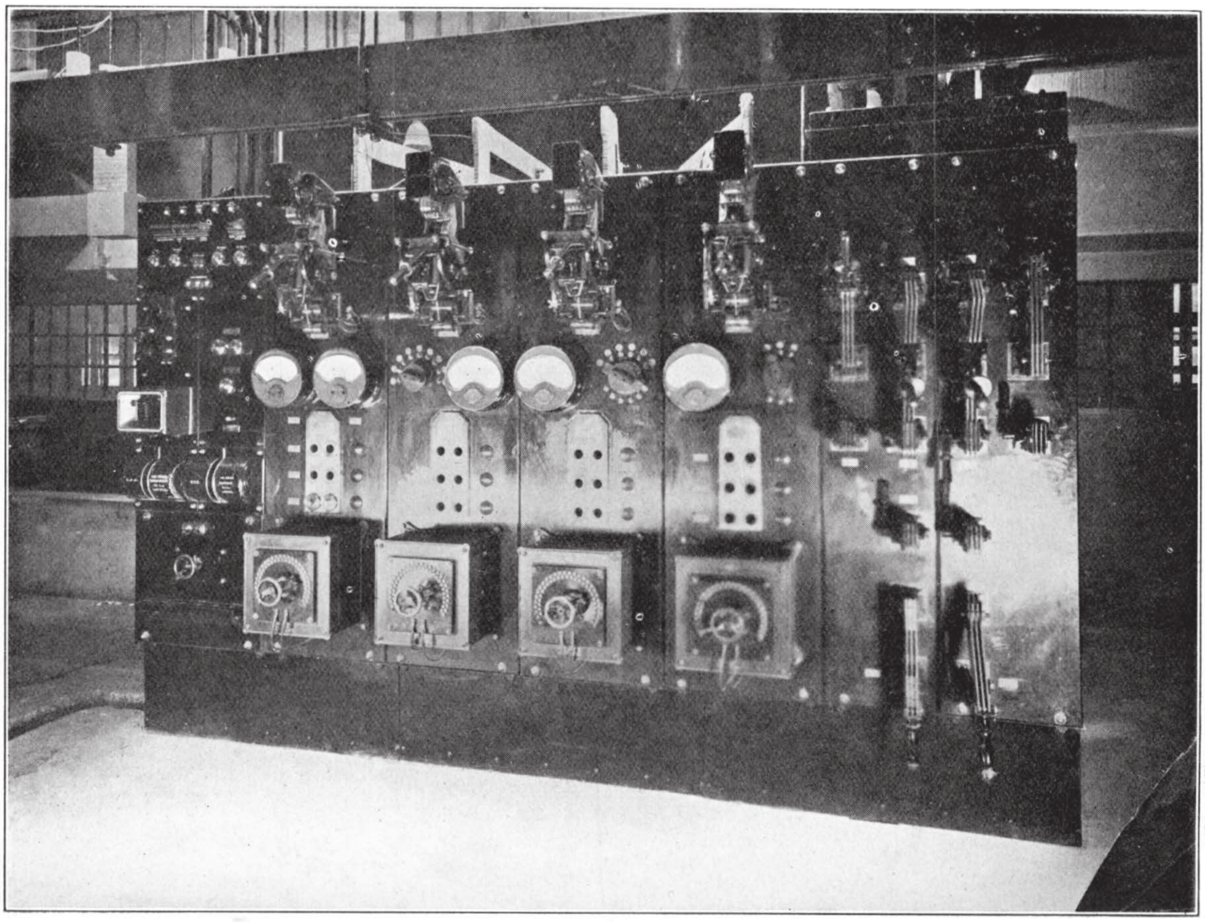


Fig. **3**.—Power Board, Tandem and Holborn Exchanges.

The Mechanical Tandem discharge circuit comprises 3 copper bars 8″ × ½″, giving 12 square inches, that of Holborn Automatic two bars 8″ × ½″, these large sections being needed to keep the voltage variations at the apparatus within the prescribed limits. The vertical conductors are actually suspended at their upper ends and clamped firmly in guides down the column to allow for any slight expansion due to increase of temperature. Joints occur every 10 feet and a liberal overlap is allowed. The surfaces are trued, tinned, cleaned again and immediately coated with vaseline before being bolted up by six ⅝-inch steel bolts. The positive conductors are insulated from their supports by micanite sleeves and plates, except in the case of those conductors which are peculiar to the discharge circuit. The negative conductors are insulated from their supports by both micanite sleeves and porcelain sleeves and blocks and are taped throughout their length, except that between floors the whole of the conductors are rendered inaccessible by being boxed in with uralite sheets. Uralite box covers are provided at joints where taping was difficult.

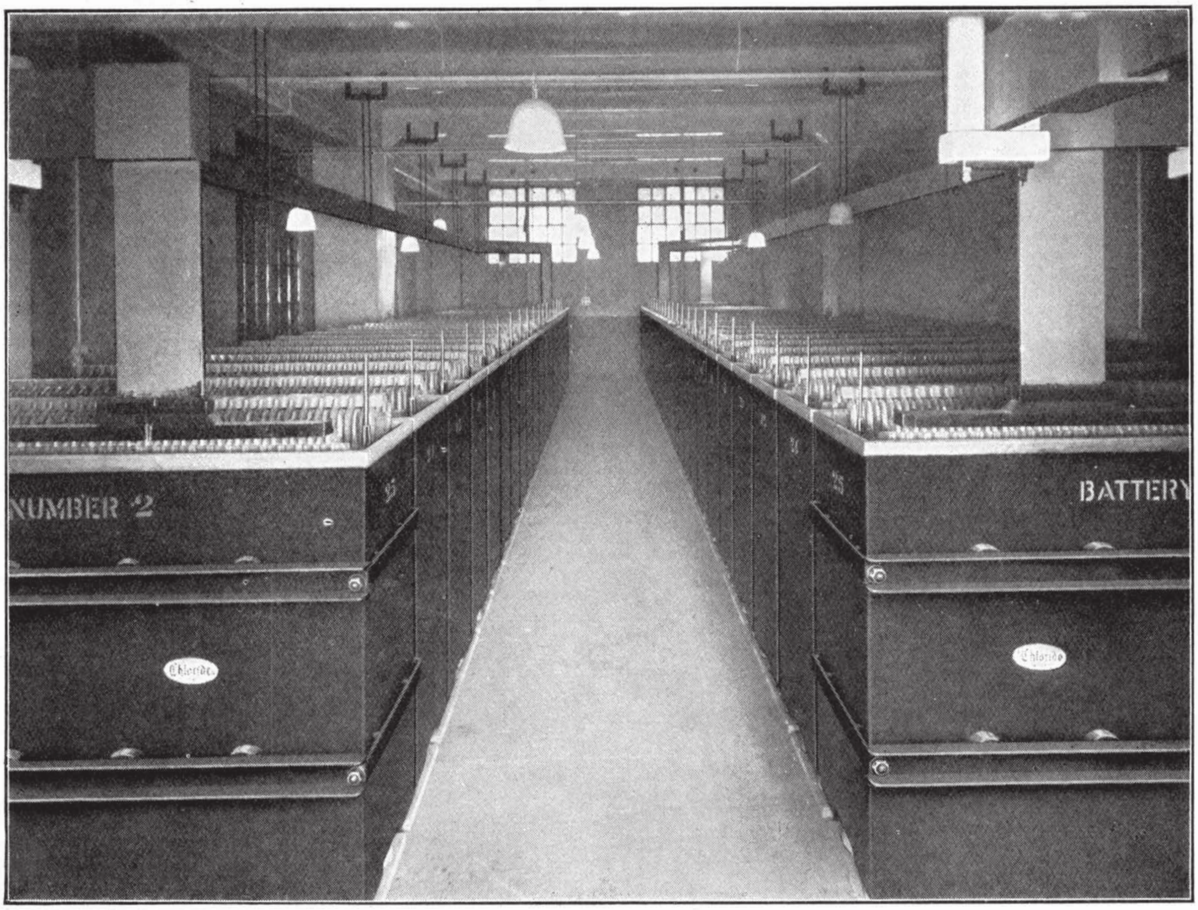


Fig. 4.—Battery Room, Holborn.

Owing to the difficulty of providing chase accommodation for the heavy cables (sometimes two conductors of 1 square inch section in parallel) used to connect up motors and generators, a new feature was introduced in the provision of pits, 3′-6″ square and 3 feet deep, formed beneath the generator commutators. The four pits were joined to one another and to the power board and other points by a nest of ducts laid at a low enough level to permit ordinary wide floor chases for the motor cables to cross them, the ducts being used for the generator cables.

The cables connecting the motor control pillars to the supply companies' services were armoured V.I.R. cables of 1 sq. inch section run overhead on hangers.

The Distribution circuits from the D.F.B.'s to the small fuse panels on the racks are formed of V.I.R. cables run overhead on racks, the cross-section being designed for a drop not exceeding 0.25 volt at full load. The negative distribution cables are taken through enclosed fuses of suitable sizes, the largest being of 150 amperes rated current. Each of these distribution fuses is shunted by a small alarm fuse. Tests have been made to confirm that the alarm fuses blow quietly without injury when the main fuse is blown by a deliberate short-circuit.

Power Board.—The Power Board, shown in Fig. **3**, is interesting mainly on account of the capacity of the switchgear. Plug busbars are used to enable any machine to be used for charging any battery or for floating on either exchange, as they provide a more compact arrangement than could be attained by the use of switches. Such switches as had to be used are of a design new to Post Office exchanges. The blades forming contacts pass through rectangular holes in the slate and form the connecting lugs at the back. Powerful clamps are provided on all contacts to improve the contact and reduce the drop to a minimum after the switch has been closed. An overhead and reverse circuit breaker is provided for each generator, as any three might have to run simultaneously. The choke coil can be used in series with any generator to supply current to either exchange, with or without a battery in parallel to share the load. The latter condition will be an emergency one only, as the machines will not give a sufficiently silent supply without a battery.

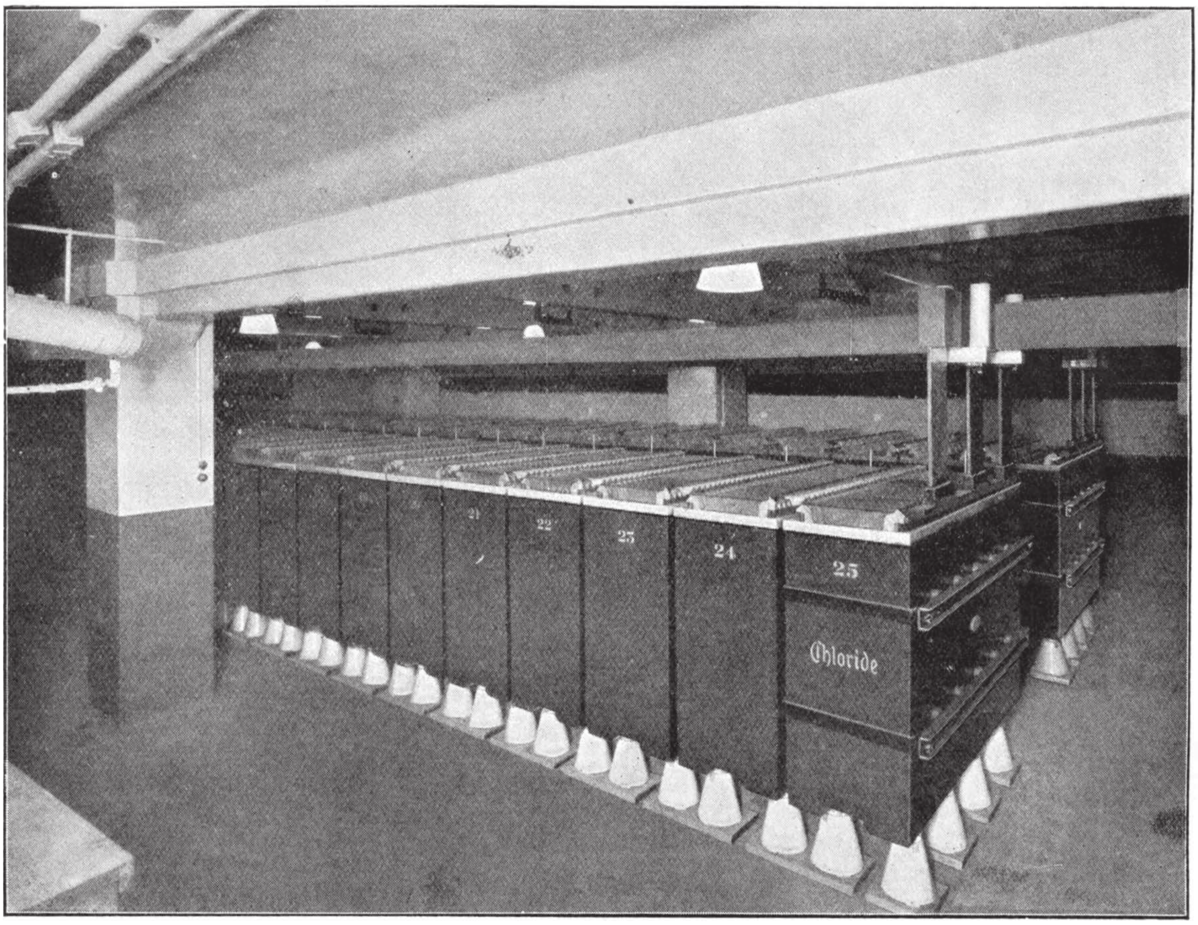


Fig. **5**.—Battery Room, Tandem.

The choke coil supplied with the machines comprises an iron wire core of 50 square inches cross-section, wound with 20 turns of copper strip, outside which a return path for the flux is provided by an equivalent section of iron wire arranged concentrically in bundles.

The connections of one motor generator and the four batteries are shown in Fig. **7**. The circuit of the motor control pillar indicates how the multiple start lever M.S.L. closes the operating coils of the two contactor switches on its first movement from the off position after the isolating switch has been closed. The starting resistances are now cut out step by step by a drum controller which operates a series of switches and is worked round by a ratchet when the starting handle is rocked to and fro. The no volt release, two overload trips and push-button release all operate by opening the main contactor holding coil circuit, and are thus operative during starting and running. In its final position the M.S.L. closes the operating coil of an additional heavy contactor which shunts out the lighter switch contacts used in the main circuit during starting. It will be seen that the vertical plug bars are each connected to a generator and are mounted on the front of the board. The three horizontal bars are connected to the two charging circuits and the floating circuit respectively and are mounted on the back of the board.

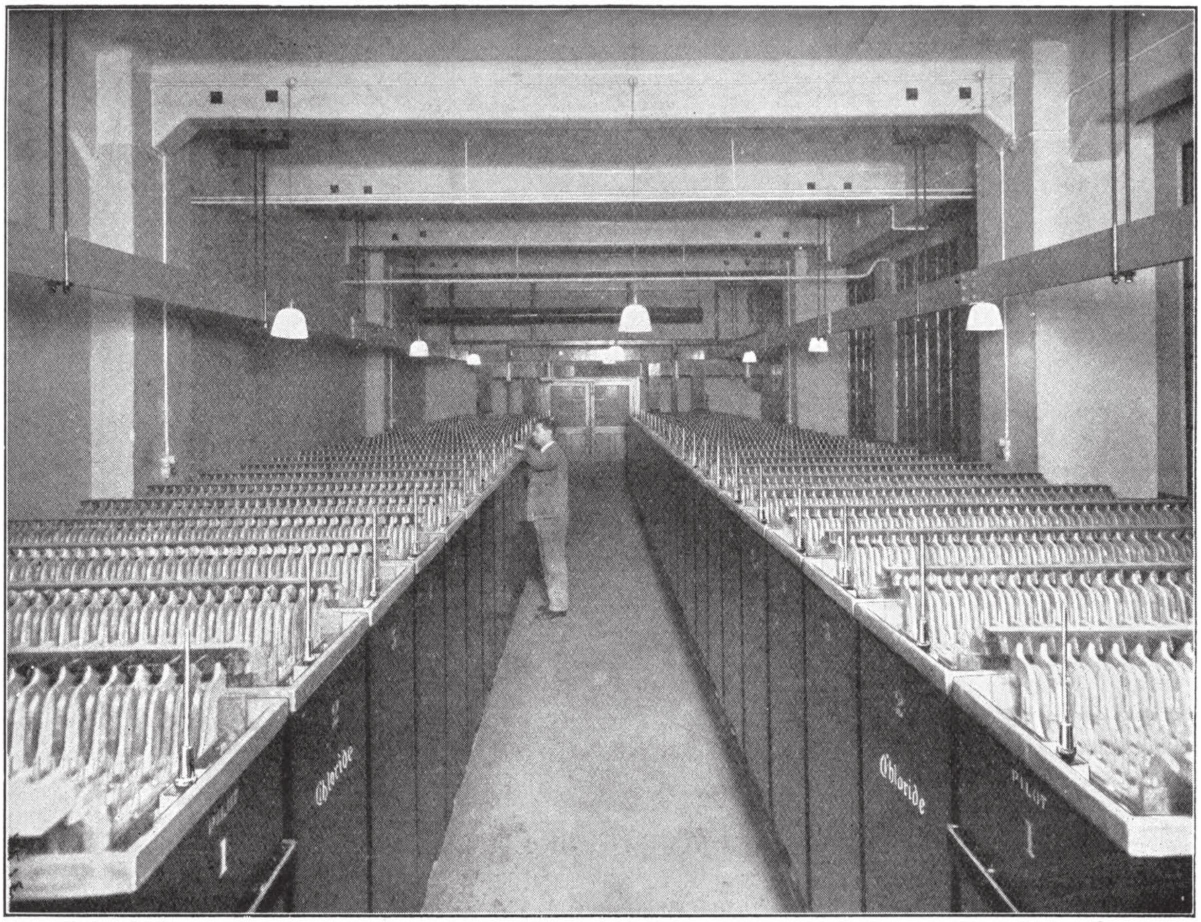


FIG. **6**.—BATTERY ROOM, HOLBORN.

Ringing Machines and Interrupters and Automatic Change Over Gear.—The Ringing Machines give an output of 4 amperes at 75 volts at a full load efficiency of 55%. High speed drum-interrupters and low speed cam-interrupters have been used.

A corner of the ringing machine pier can be seen on the extreme left of Fig. **1**. The switchgear controlling the ringers is mounted on the left-hand panel of the power board (Fig. **3**).

The Ringer and Interrupter circuits are shown in Fig. **8**, which was prepared by Mr. Gillings, of the A.T.M. Coy., on the detached contact principle.

The diagram is largely self-explanatory, but attention should be drawn to certain features, including the method adopted for automatic changing over to the reserve ringer on failure of the normal machine. The 200-volt ringer is normally in use and RF is operated as long as the supply of ringing current is maintained. The 8-pole and 6-pole change-over switches A for code selector racks and regular selector racks supplies current to S.T.1 when RF releases. 6-pole change-over switch B. This falls into its lower position and cuts out the starting resistance at 9, allowing ringer 2 to run up to full speed.

The circuit breaker is fitted with a thermo element to operate a trip coil with sustained overload but not with the heavy starting current of short duration. It also has a no voltage release coil which holds contact N.V. open so that when the 6-pole switch is in its lower position the circuit of the trip coil is only prepared and not completed by pole 14.

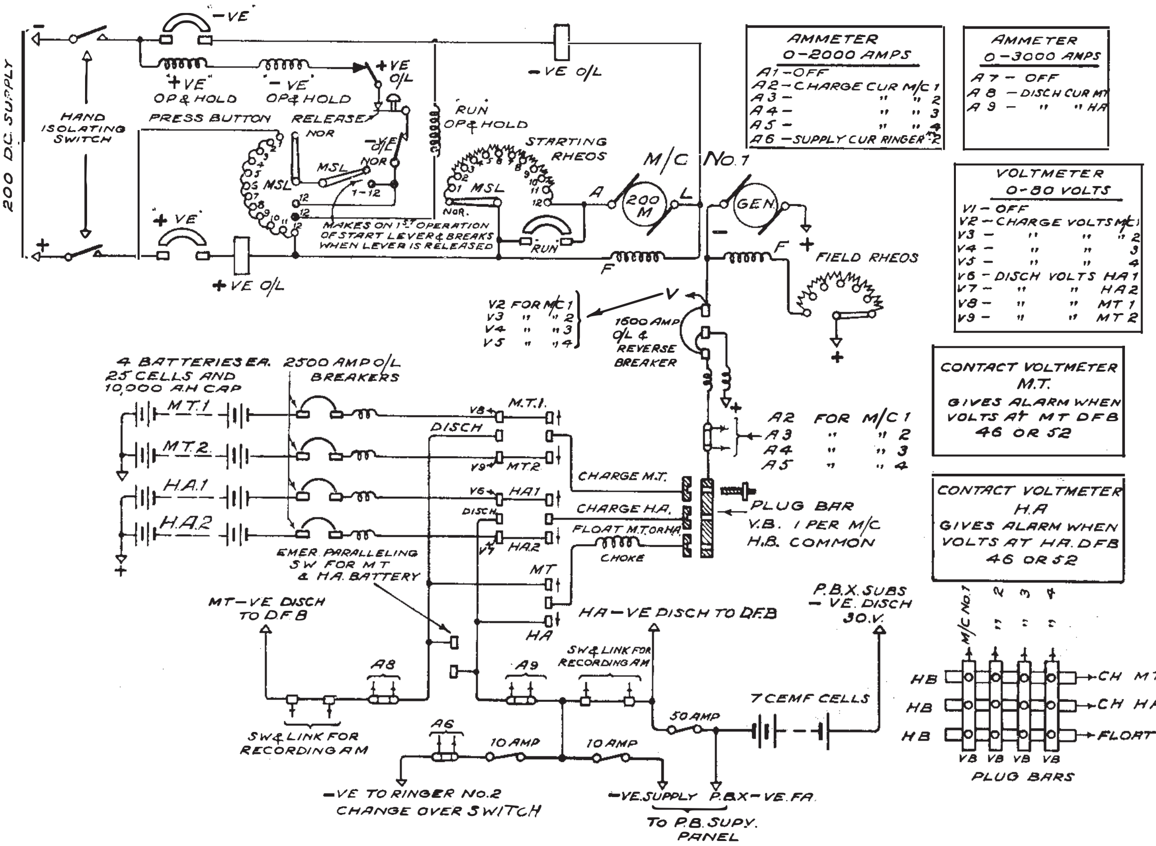


Fig. 7.—Connections of Motor Generators.

S.T.1 places a short across the contacts of RF at X and closes the circuit of trip coil A of the 8-pole switch at S.T.1. The 8-pole switch then falls into the lower position by gravity and contact 1 completes the circuit of the battery ringer through the circuit breaker of the " Panel motor starting No. 1 " and a starting resistance.

When Ringer 2 has gathered sufficient speed, R.C.O. pulls up and closes a circuit for W, which locks at X and completes a circuit for S.T.2. S.T.2 gives an alarm and also completes the circuit of the trip coil B, which releases the

It will be seen that the change-over switches A and B, in addition to starting up the reserve ringer, also change over the exchange circuits from the normal to the reserve ringer. These circuits include continuous ringing, three phases of interrupted ringing, flicker and flash circuits, interrupted circuits of the primaries of three tone transformers and the interrupter controlling the busy dividing relay BD of the new busy flash circuit.

The busy tone of 400 cycles per second passes through the main busy back transformer BB, and then through a tuned filter circuit to eliminate the more powerful harmonics. The filtered alternating current, feeds, in parallel, two "Number Unobtainable" tone transformers, for code selector racks and regular selector racks respectively, and, in addition, all the transformers associated with half the busy flash and hold equipments of the exchange.

One such Busy Flash and Hold Equipment is shown complete and one in part.

tone transformer secondary.

Earthing.—In attempting to observe the Regulations of the I.E.E. for the Electrical Equipment of Buildings regarding the earthing of the machine frames, a curious difficulty presented itself. The motors take 575 amperes at 200 volts from a 3-wire (100 + 100 volt) system and their overload trips could hardly be set below 850 amperes. The earthing conductors were required to have a sectional area of 0.5 square inch and in the event of an earth fault on a motor would be called upon to carry at least this current at 100 volts. The resistance of the earth circuit *via* the earth plates would, of course, be far too high, even without making allowance for the resistance of the earth connection at the supply company's sub-station.

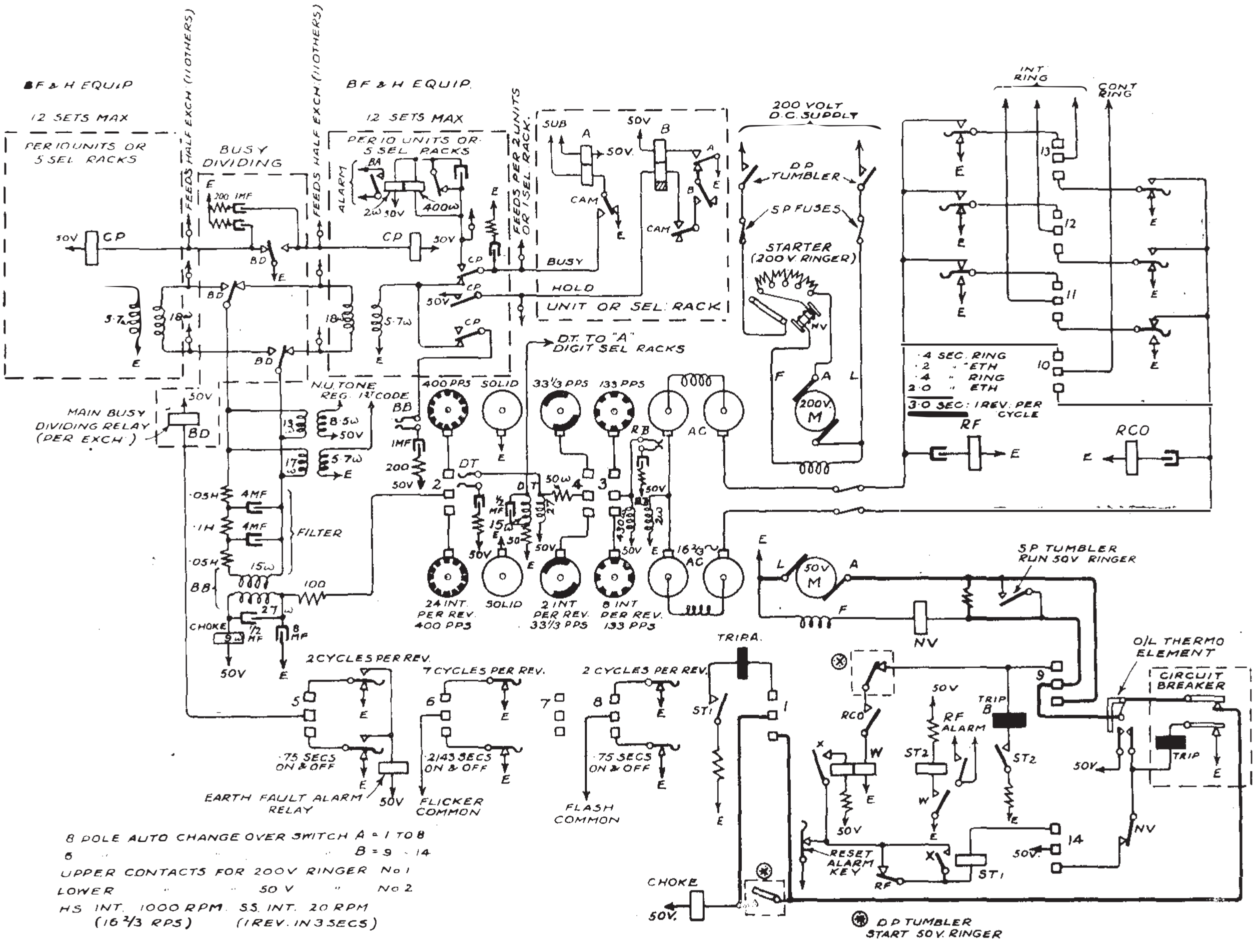


FIG. 8.—CONNECTIONS OF RINGERS, INTERRUPTERS AND TONE CIRCUITS.

The function of BD is to feed each half of the B.F. and H. equipments with tone for .75 sec. alternately, and simultaneously to control their C.P. relays.

Each C.P. relay, operating at .75 second intervals, alternately connects battery to the subscriber's line through the A relay and simultaneously to the holding winding of the B relay to prevent its release, and the subscriber's line through the A relay to earth, by way of the

At the exchange all the street cable sheaths would normally be bonded to the exchange earth bar and would probably provide a sufficiently low resistance earth circuit at some risk to themselves, as the current would not be uniformly distributed among them.

The use of the Metropolitan Water Board's main would have involved special permission and the separation of all emergency earth connections from those through which small currents may flow permanently. A good connection to this main would be a matter of considerable difficulty.

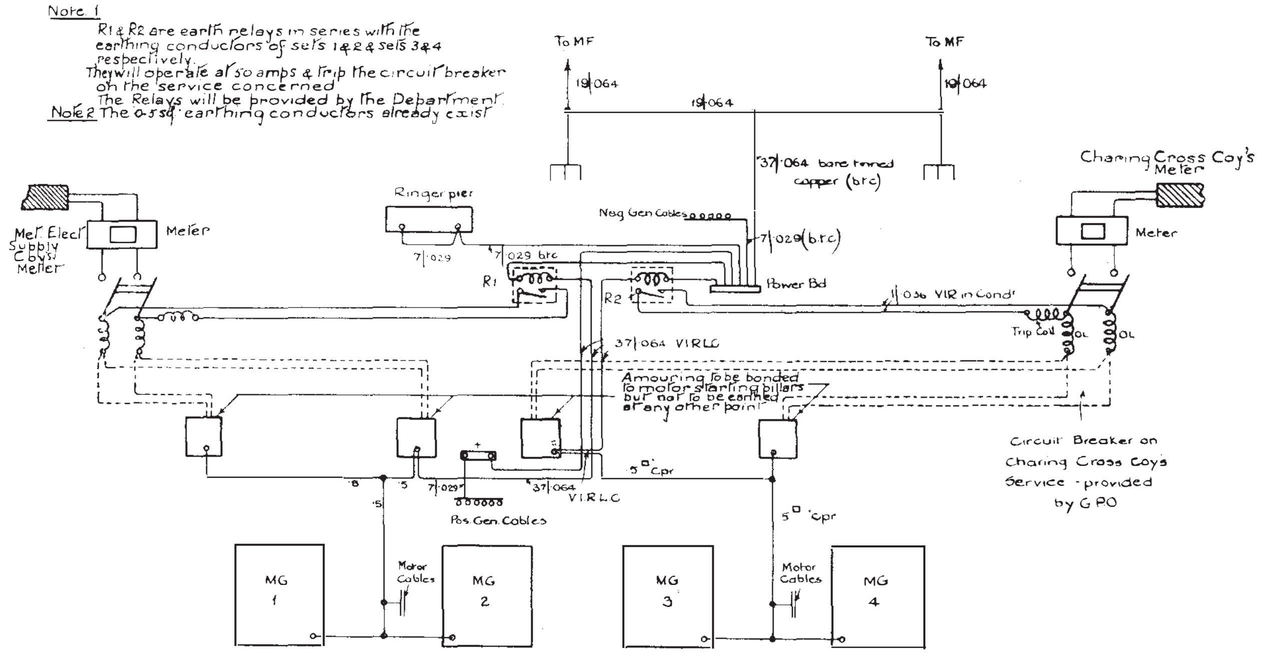

Note 1
R1 & R2 are earth relays in series with the earthing conductors of sets 1 & 2 & sets 3 & 4 respectively.
They will operate at 50 amps & trip the circuit breaker on the service concerned
The Relays will be provided by the Department.
Note 2 The 0.5 sq earthing conductors already exist
To MF
19/.064
19/.064
To MF
19/.064
37/.064 bare tinned copper (b.r.c)
Charing Cross Coy's Meter
Met. Elect Supply Coy's Meter
Meter
Ringer pier
Neg Gen Cables
7/.029 (b.r.c)
Meter
7/.029
7/.029 brc
R1
R2
Power Bd
1/.036 VIR in Cond.
Trip Coil
OL
OL
37/.064 VIRLC
Amouring to be bonded to motor starting pillars but not to be earthed at any other point
Circuit Breaker on Charing Cross Coys Service - provided by G PO
·8
·5
·5
7/.029
+
37/.064 V.I.R.L.C
5 □" Cpr
Pos. Gen. Cables
5 □" Cpr
MG 1
Motor Cables
MG 2
MG 3
Motor Cables
MG 4

Fig. 9.—Connections of Earthing Cables.

In the circumstances the earthing conductors have been connected to earth through a relay which will trip at 50 amperes and close a special trip coil of a circuit breaker on the supply company's main service. The earthing connections are shown in Fig. **9**.

The Institution of Electrical Engineers was consulted, and in the September, 1926, amendments to their Regulations they have limited the maximum size of earthing conductors to 0.1 square inch.

The installation as a whole has been carried out by the Automatic Telephone Manufacturing Company, with the help of the following sub-contractors :—

Motor-Generators, Choke Coil and Ringers—Messrs. Newton Brothers, of Derby.

Batteries—Chloride Electrical Storage Company.

Power Board, Battery Circuit Breakers and Main Connections—Messrs. Bertram Thomas.

Motor Control Pillars—Messrs. Brook-Hirst.
Crane—Messrs. Herbert Morris & Co.

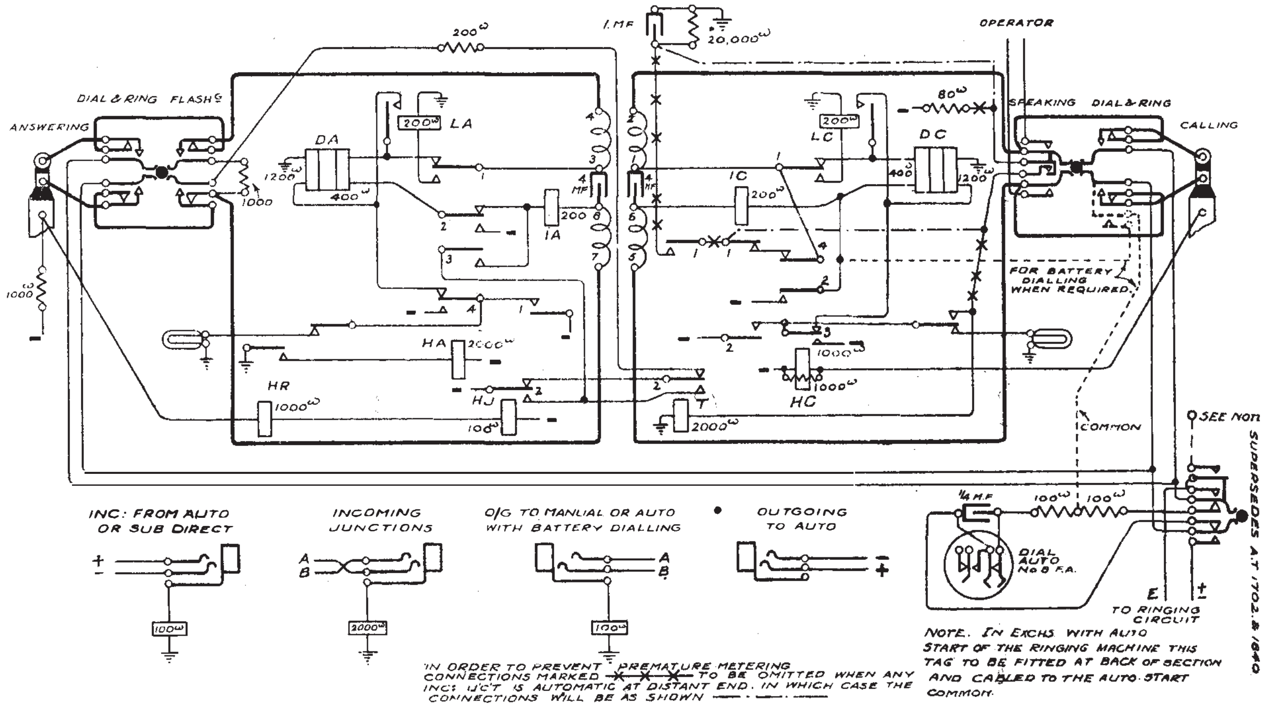
TIME SAVING TESTERS.

FOR AUTOMATIC EXCHANGES.

W. Prickett and H. S. Smith.

ALTHOUGH most of the traffic in an automatic exchange area is dealt with mechanically, the services of the manual operator are still utilised for trunk and fee junction calls and enquiry and similar services.

The circuits carrying such traffic usually terminate in the central exchange of the area on a small manual switchboard of the No. 10 type, provided with equipment which has been developed to provide the numerous special facilities required. It will be seen from the first diagram, which shows a typical cord circuit, that the arrangements differ considerably from those ordinarily met with in manual exchanges.



IN ORDER TO PREVENT PREMATURE METERING CONNECTIONS MARKED —✕—✕—✕— TO BE OMITTED WHEN ANY INC: J'C'T IS AUTOMATIC AT DISTANT END. IN WHICH CASE THE CONNECTIONS WILL BE AS SHOWN —·—·—

NOTE. IN EXCHS WITH AUTO START OF THE RINGING MACHINE THIS TAG TO BE FITTED AT BACK OF SECTION AND CABLED TO THE AUTO-START COMMON.

Fig. 1.—B Cord Circuits with Repeating Coils. Manual Positions, Auto. Exchanges.

In order that these circuits may be thoroughly tried out before being brought into use, and efficiently maintained in service, suitable testing arrangements have been made and it is now proposed to give a brief outline of some of the tests made on cord circuits.

Tester No. 59.—Tester No. 59 is a portable instrument, arranged for attachment to the wheeled testing stand, which is a familiar object in automatic switchrooms, in order that it may be placed where required close to the switchboard. The tester is provided with a series of jacks for the connection of the circuits to be tested, and keys to enable a variety of test conditions to be rapidly applied. Results of the tests are checked by observation of the tester and cord circuit lamp signals. The internal connections of the tester are shown in the second diagram.

To bring the tester into use, the battery plug is inserted in one of the switchboard power jacks and the required plug of the cord circuit to be tested is inserted in the appropriate jack on the tester. The tester keys are then operated in acordance with the schedule referring to the type of circuit concerned and the lamp signals on the tester and on the keyboard are checked against the specified results. A copy of a typical schedule covering tests on the cord circuit illustrated is here reproduced.

SCHEDULE OF PROCEDURE WHEN USING TESTER No. 59.

Circuit under Test.	Cord.	Procedure.		Nature of Test.	Result of Test when Apparatus is O.K.
		Insert Plug in Jack.	Throw Keys.		
A.T. 812 1704 1721 *1703 *1720	Ans.	1.	6.	(*a*) Continuity of sleeve cct. Operation of relays HJ & HA (* & HR) to manual ccts.	Sup. lamp glows.
			Cord Cct. Dialling Key. Then 6 & 1 & dial.	(*b*) Dial Connections.	Tester lamps A & B glow, and respond to dial impulses.
			6 & 1.	(*c*) Operation of relays LA & DA.	Sup. lamp darkens. Tester lamps A & B glow.
			6 & 2. Then 3 also, approx. 3 times per sec.	(*d*) Release of LA after saturation.	Sup. lamp glows, then darkens on operation of key 3 and glows on release.
			7.	(*e*) Non-Operation of HR & HJ to auto. ccts.	Sup. lamp does not glow.
			7 & 1.	(*f*) Operation of IA & non-operation of DA.	Sup. lamp glows. Tester lamps A & B glow.
			7 & 2. Then No. 3 also, approx. 3 times per sec.	(*g*) Release of IA after saturation.	Sup. lamp glows on operation of key 3 and darkens on release.
			7 & 1. Then No. 4 also, approx. 3 times per sec.	(*h*) Operation & release of DA on reversals.	Sup. glows, then darkens on operation of key 4 and glows on release.
A.T. 1703 1720			8. Then 1 also.	(*j*) Operation of HR & non-operation of HJ to JE Jc ccts.	Sup. glows. Sup. darkens. Tester lamp A glows (note B does not glow).
			8 & 9. Then 1 also.	(*k*) do. do.	Sup. glows. Sup. darkens. Tester lamp A glows (note B does not glow).
	Ans. also Call.	1. 6.	8 & 1. Then 10 also.	(*l*) Operation of DC & T. for through signalling.	do. do. Tester lamp B glows on operation of key 10 or cord cct. spkg. key (the latter only if through signalling on key is provided. See cord cct. diagram).

It will be seen that the answering cord should be inserted in Jack No. 1 of the tester. This connects the tip and ring conductors to the main testing circuit and the third conductor to a series of keys controlling sleeve resistances.

In test (*a*) key No. 6 is operated. This provides a sleeve resistance of 200 ohms for tests under conditions where the sleeve resistance is normally 100 ohms. The effect should be to operate relays HJ, HR and HA of the cord circuit, the operation of the last two of which is checked by observation of the answering supervisory lamp, which should glow. Relays HA and HJ also cause battery and earth to be connected to the transmission circuit *via* relays IA and LA. This condition is checked by test (*c*).

Test (*b*), for which Key No. 1 is operated in addition to key 6, provides a check for the dial circuit connections, by the connection of the tester relays A and B to the tip and ring conductors. When the dial on the keyboard is operated, the dialling key of the cord circuit having been previously thrown, the loop impulses should cause the relays to vibrate and flash lamps A and B. (Battery dialling connections are checked in the corresponding test of the calling cord.)

In test (*c*) also, Key No. 1 is operated in addition to No. 6 and applies relays A and B to the tip and ring circuit. If relays HJ and HA have functioned to provide the battery and earth feed to the transmission circuit, relays A and B operate and cause tester lamps A and B to glow. The battery feed *via* relay A under long line conditions should also operate relay LA to actuate in turn DA and extinguish the supervisory lamp.

Test (*d*), keys 2 and 3 are thrown instead of key 1 to repeat test (*c*) on relay LA, but under short line conditions with low insulation.

In Test (*e*) the sleeve conditions are changed to those met with when calls are made to local automatic circuits. The sleeve circuits of the latter are equipped with relays of 6,500 ohms resistance or in some cases are left disconnected. The cord circuit relays HR and HJ should not operate under these conditions. Key 7 connects a 6,000 ohm resistance in the third conductor as a test condition to meet the case of an automatic circuit relay, wound to less than the specified resistance figure to the extent of the five per cent. variation allowed in coil winding. A check is then made to verify that the supervisory lamp does not glow.

Test (*f*). Key No. 1 is now thrown in addition to No. 7 and provides, under long line conditions, a circuit for tester relays A and B round the cord circuit loop *via* relays DA and IA. The last mentioned should operate to cause the supervisory lamp to glow.

Test (*g*). Keys 2 and 3 are thrown instead of No. 1 to repeat test (*f*) under short line conditions.

Test (*h*) repeats test (*f*) with the additional feature of providing a reversed current corresponding to the supervisory signal supplied by a final selector when a subscriber answers a call.

In tests (*j*) and (*k*) the conditions set up by keys 8 and 9 provide marginal figures corresponding to the 2,000 ohm sleeve circuit of a jack-ended junction. In this test, relays HR and HA in the cord circuit should operate, but HJ should not. The operation of HR and HA is proved correct by a glow on the supervisory lamp and the non-operation of HJ by the absence of the battery circuit through IA preventing the operation of tester relay B and lamp B.

Test (*l*) proves, by the glowing of lamp B, that continuity of this circuit through IA has been established to provide conditions similar to those obtaining when a through call is completed to a subscriber. This test necessitates the insertion of the calling cord in jack No. 6 and the operation of key No. 10.

The tests on the calling cord are made with the aid of a similar schedule. Engaged test circuits are checked by means of the operator's set or the telephone circuit and key 5. The latter is also used for transmission tests in conjunction with any convenient circuit to the test desk. Dial speed tests are also made over the test desk circuit.

The facilities provided by the tester cater for tests on all 50-volt cord circuits including plug-ended junctions. Provision is also made for tests on many other circuits, such as jack-ended junction and trunk calling equipments and for the ringing supply.

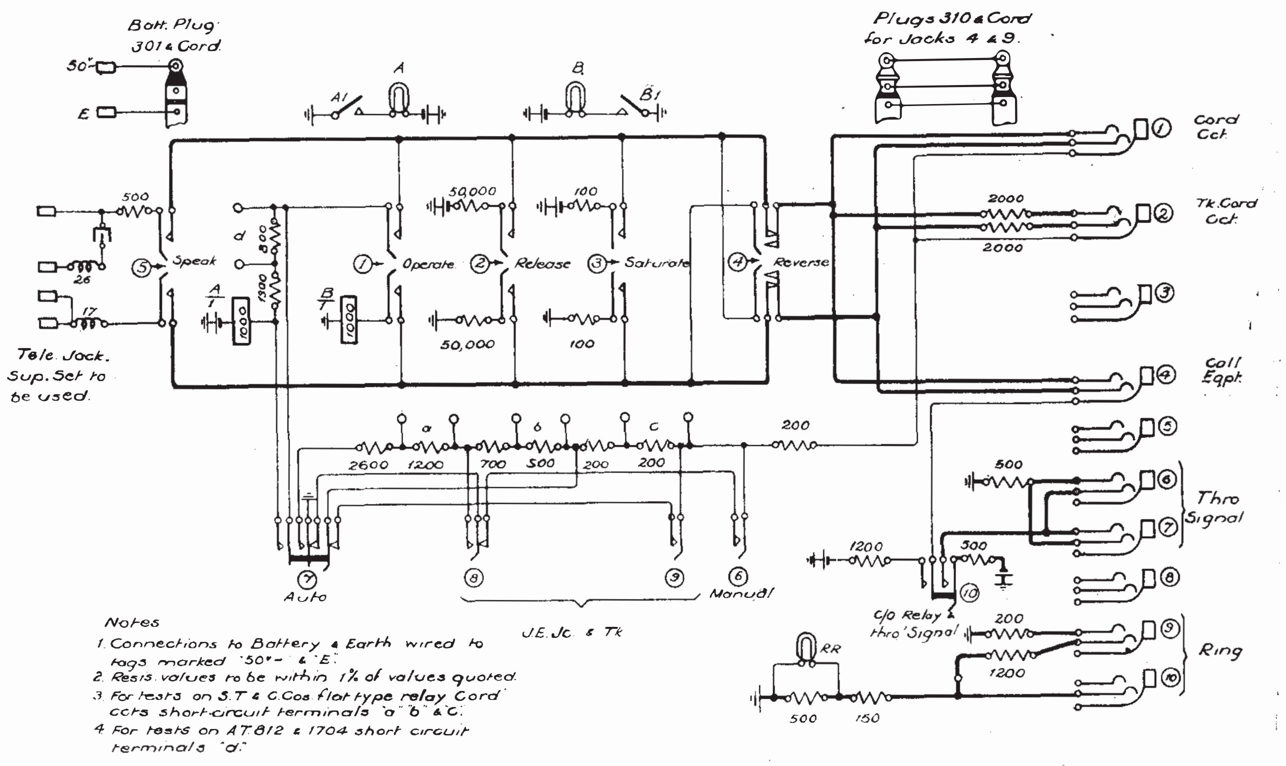


FIG. 2.—TESTER NO. 59. FOR TESTING CORD CIRCUITS ON MANUAL BOARDS, AUTO EXCHANGES.

THE TRAFFIC-OFFICE OF THE MUNICIPAL TELEPHONE SERVICE AT AMSTERDAM.

Dr. Ir. Ch. E. A. Maitland.

THE scientific investigation of traffic problems can be divided into the following parts :—

A.—Traffic as a collective phenomenon.
B.—Traffic from the individual subscribers' lines.
  (1) Seen from the management's point of view.
  (2) Seen from the subscriber's side.
C.—The internal traffic in P.B.X. installations and its influence on the system as a whole.

There has been a period during which neither in telephone construction, nor in management has traffic been considered as a problem; but with the growth of the system and particularly after the introduction of automatics it has been generally admitted that to construct a telephone exchange without taking into consideration the traffic is as wrong as building a bridge without sufficient knowledge of the load. There is a difference, however. The variations in the load of a telephone exchange and the influence that the individual use of the subscribers' lines exercises on the traffic and the traffic distribution in the system necessitate the continuous study, supervision and control of the traffic in the daily management of telephone systems.

This will be possible only by introducing into the organisation a special service adapted thereto, *i.e.*, the traffic office, having as its function the handling of this kind of problem. This is not generally recognised and very often the assumed costs of such a traffic office prevents its installation though they are undoubtedly less significant than the disadvantages of an inefficient distribution and disposal of traffic causing traffic losses, complaints, troubles and waste of material and labour. The costs of those items, however, never appear as a whole in the accounts and therefore are always underestimated. As soon as this is acknowledged the traffic office is established and in a short time proves to be one of the most important parts of the organisation.

There is, however, a danger in all such services that deal with scientific investigation, and the real proportions of its task must not be lost sight of. It must be seen that "l'art pour l'art" is not exercised and that only such problems are taken into consideration as have a present or probable future interest for the service. The traffic manager must be a man with scientific sense, but also with a practical view on management.

A.—Traffic as a Collective Phenomenon.

(1) *Measuring the traffic flow.*

The traffic flow originates from the network of subscribers' lines and returns thereto. The exchange first collects traffic and then distributes it in different paths, *e.g.*, the total traffic emanating from a group of 2000 lines is collected on the 1st Group Selectors and then distributed by the 2nd Group Selectors, 3rd Group Selectors and Final Selectors.*

In each of these paths the traffic flow can be measured, and the losses determined.

The easiest way to do this is to measure the total working-time of all the switches in a traffic path, the traffic being measured in a time-unit, *e.g.*, hours, minutes or seconds. It is, however, also possible to choose another scale, viz.: the number of connections. There arises a difficulty because there is a difference between the number of calls and the number of completed connections, and again between those two and the number of answered calls, only the last category being measured for rate purposes.

For this reason the number of connections is not suitable as a unit for the measurement of the traffic flow, and for investigating traffic as a collective phenomenon it is much better to use a time scale (T.C.).†

To analyse the individual traffic per line, however, a knowledge of the number of calls is indispensable.

Two items are rather easily available, the number of calls and the number of completed and answered connections, the last being the base of the rate schedule.

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* *For full particulars see P.O.E.E.J., Vol. 19, Part 2, July, 1926, p. 153.*

† *T.C. is the equivalent of the British term "Traffic Units."*

For automatic telephony a call means a 1st G.S. put into action, that is to say the first digit must be dialled. Taking off the receiver from the subscriber's apparatus makes the first selector busy, but this cannot be considered as a call. Therefore calls are registered as the 1st G.S. turns in under the action of the rotary magnet.

For semi-automatic offices the number of calls is registered on the operator's position.

The number of conversations is recorded from the message registers.

The difference between the number of calls and the number of conversations means lost traffic. This consists in:

(*a*) The uncompleted connections (owing to the subscriber).

(*b*) Failure of connections (owing to the equipment).

(*c*) Calls resulting in busy-signals.

(*d*) Unanswered calls.

At Amsterdam the traffic flow is *permanently* measured on the 1st and 2nd G.S. and so also are the number of calls and the number of conversations.

The day period is counted from 9 a.m.—5 p.m. and the night period from 5 p.m.—9 a.m.

This means permanent supervision of traffic in all paths where deviations from the normal would be harmful to the service.

During the day period measuring is done by recording ammeters, running 240 m.m. an hour. The instruments are calibrated to the number of switches that are in action and measuring current is supplied through a resistance specially mounted in each switch for this purpose. This current flows from the moment the selector is connected to the calling line. It will be noticed that time is recorded even when no call follows, *e.g.*, short circuits, receiver off switch-hook, etc. Dividing the time by the number of calls, the average time per call will be found a little too large, but this fault is less than would be made by recording all these cases as real calls.

The recording ammeters are supplied with flameproof celluloid films instead of paper bands. The length of a film suits the period from 9—5. The advantage of this method lies in its economy as the films can be washed after use. For interesting cases they are blue printed or photographed and for the sake of comparing two or more simultaneously recorded curves the films can be superposed as can be seen from the specimens.

Fig. 1 shows the assembly of the instruments in the traffic office for central office No. 3. The instrument No. 3 from the left, records the total traffic on the 1st G.S. in central office No. 3 (C.B.3).

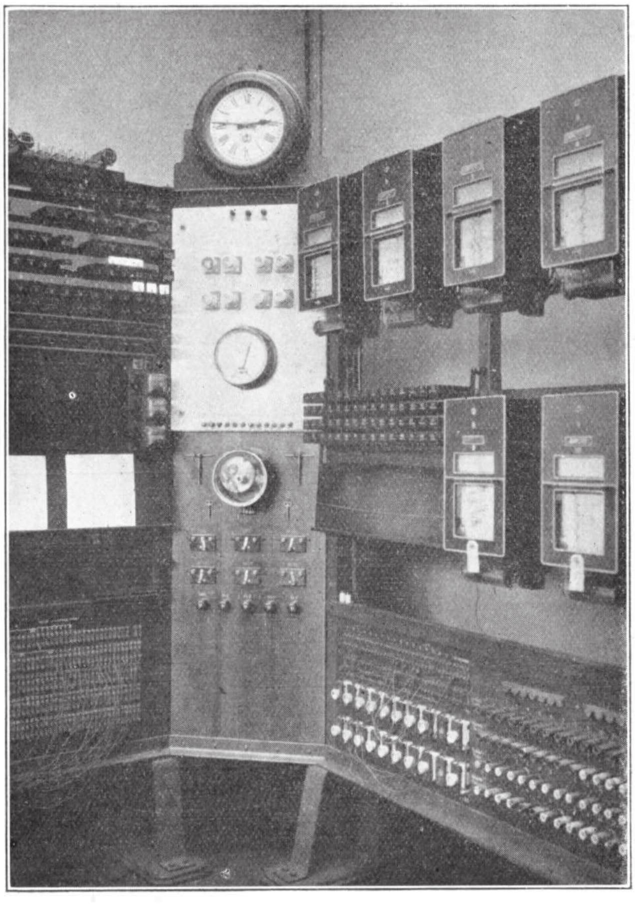

FIG. **1**.—INSTRUMENT ROOM OF TRAFFIC OFFICE.

Sometimes it is useful to split up the record among groups of 2,000 lines. This can be done with one ammeter, as shown in **Fig. 2**, the instrument being connected in each group temporarily for a minute at a time by means of a clock-operated relay. The same electric clock draws a line on the film every hour. The curves on left of **Fig. 2**, are for groups of 4,000 and 10,000 lines respectively, those on the right for 5 separate groups of 2,000 lines.

During the night period measuring is done with electrochemical electricity meters. In the semi-automatic offices there are two additional meters recording respectively the waiting time before a calling subscriber is connected to the operators' position, and the number of operators on duty. In conjunction with the number of calls handled by the operating staff, the first item gives the average waiting time per call, and the second the average load per telephonist per hour.

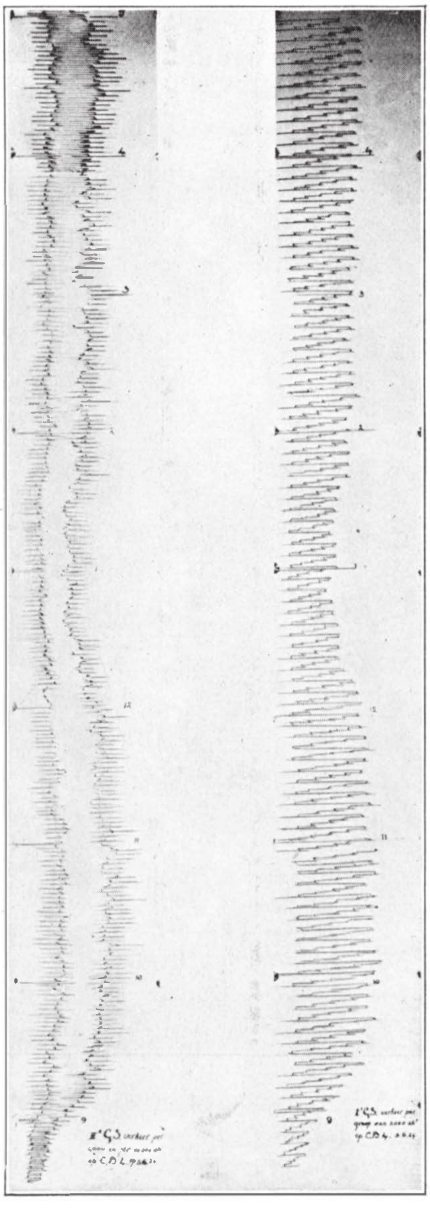

FIG. **2**.—TRAFFIC ON FIRST GROUP SWITCHES PER GROUP.

In Figs. **3** and **4** are shown examples of the superposition of curves for the traffic, waiting calls and operators on duty (the last curve has zero to the right) from which their mutual influence can be observed.

The average load per operator is 425 calls an hour; the operating time per call is 5.9 sec., so that the efficiency of operating is 0.7. The average waiting time for the operator to answer in the busy-hour is 2.1 sec., and the number of wrong connections 1.5 % (see Table III.).

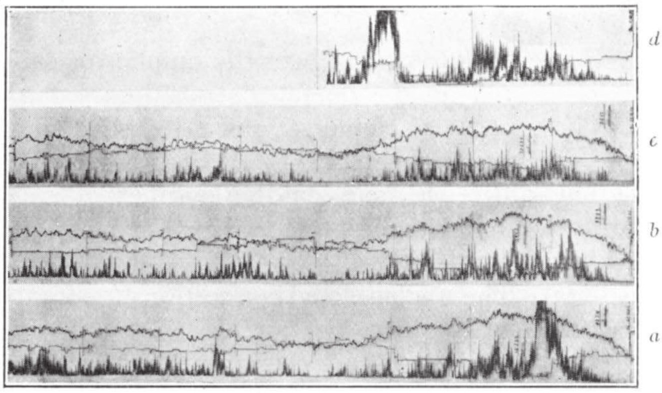

FIG. **3**.—SUPERPOSED TRAFFIC CURVES.

Sharp control by the traffic office reduces operating faults to a minimum and supplies much useful information to the chief operator, teaching her how to deal with the regular and also the special variations of the exchange load.

The films of the recording ammeters are planimetered every hour and the results are systematically recorded in a card system (Kardex-visible-Index) together with the peak load of the group.

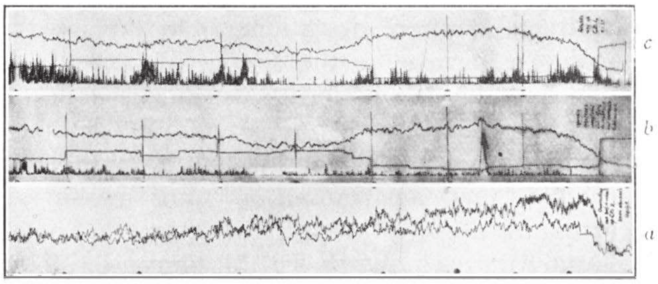

FIG. **4**.—SUPERPOSED TRAFFIC CURVES.

Likewise are treated the periodical records of traffic on 3rd G.S. for each group of 1,000 numbers, and of the Final Selectors per group of 100 lines.

The card system therefore contains a very compact summary of the critical traffic data and a running record of the load in all the stages of traffic distribution, showing the efficiency of each group of switches and the progressive change of the load owing to the normal extension of the system.

This facilitates, by means which will be dealt with later on in this article, the calculation of the number of switches in accordance with the traffic and the promotion of the most economical load for the groups.

The average efficiency of the 1st G.S. has been taken at 70%, that of the 2nd and 3rd G.S. at 50% and that of the final selectors at 30%. The number of switches simultaneously working in accordance with these data is marked with a red line on the instrument, and so long as the curves remain on or below this line no loss of traffic because of shortage of outlets from the switches is to be feared.

In semi-automatic offices the efficiency of the 1st G.S. can be increased up to 85% by a small extension of the waiting time. The same effect can be reached in full automatic systems by introducing the dialling tone, which ordinarily in the Strowger system can be dispensed with. Up to the present no dialling tone is used at Amsterdam, though all the necessary devices are provided for.

The statistics recorded in the card system allow of the calculation of a great many traffic data and their verification as to constancy. Two examples will be described.

(2) *Acquaintance factors.*

If traffic measured in terms of T.C. outgoing from the office I to the office K be called a_{ik}, the total traffic outgoing from I be a_i, and from K a_k, then the acquaintance factor for the traffic from I to K is

$$f_{ik} = \frac{a_{ik}}{a_i a_k} \Sigma a$$

Σa being the total traffic of the system.

$$a_{ik} = f_{ik} \frac{a_i a_k}{\Sigma a}$$

The acquaintance factor f_{ik} has a value between 0, when no traffic from I goes to K, and $\frac{\Sigma a}{a_k}$ when all of the traffic from I goes to K.

The acquaintance factors determine the character of the exchange in the network and its relation to the other offices, they supply the necessary data for the calculation of junction traffic and the number of junction lines and switches (2nd G.S.).

It is interesting to know in how far those acquaintance factors are constant, during the variations of the load in the day period and whether they change much over several years under the influence of the extension of the city and of the telephone system.

The acquaintance factors for Amsterdam are calculated every year for two or three months and from 1924 up to the present they show exactly the same figures. To demonstrate the variations during the day period, the acquaintance factors for May, 1926, are reproduced in Table I.

From the figures it will be seen that C.B.2 is a typical suburban exchange, C.B.3 and C.B.4 are the city exchanges and C.B.5 has a character just between.

(3) *Lost Traffic.*

Calling the traffic flow in terms of T.C. on 1st G.S. I_1 and on 2nd G.S. I_2, the traffic loss

$$V = \frac{I_1 - I_2}{I_1}$$

V amounts to 25% in the semi-automatic office C.B.4 as an average for the day period calculated over a year, and in the full-automatic exchange C.B.5 to 15%. This figure is not constant when considered month by month, it varies in the two cases between 22 and 28%, and 10 and 18% respectively.

Included in the traffic loss mentioned above are the calls for booking toll connections, amounting to 4% in C.B.4 and 2% in C.B.5.

The analysis of the loss runs further, as follows:—

(1) 2½% normal loss owing to the fact that the 1st G.S. must have worked before the second G.S. is put into action.

(2) ½% results from normal busy calls (3 sec. per call).

There remains 18% in semi-automatic and 20% in full-automatic offices. In the former 8% is the normal time expenditure for the service, waiting time, setting up the keyboard, etc. In both types of exchanges there remains 10% real loss of traffic, which has been occasioned by various causes, *e.g.*, unnecessary listening to the busy signal (which is given from 1st G.S.), uncompleted connections, dialling on a level not in use, leaving receiver off switchhook, shorts on the line, poor service on P.B.X.'s, etc. All those avoidable losses ought to be detected and, if possible, reduced by the traffic office. This leads to a close examination of the traffic on the individual subscriber lines, as being one of the most important details of the task of the traffic office.

The next process in the analysis of the traffic loss is the comparison of the number of calls and the total number of conversations that are accounted for. The proportion of these two figures is calculated every 24 hours and proves to be always between 69 and 71%. The percentage of lost calls in 24 hours is fairly constant and is the same for all the exchanges, semi- or full automatic. Calculated over the various hours of the day period the loss varies from 32% in the busy hour to 22% in the slack hours.

The analysis runs as follows :—

	S.A.*	F.A.
(1) Calls not accounted for owing to rate schedule, principally calls for booking toll connections	2-3%	2-3%
(2) Subscriber orders no number or is unintelligible	1.5%	—
(3) Interrupted connections	1.5%	0.5%
(4) Call reaches a spare level	0.5%	3.5%
(5) Uncompleted connection	—	1.5%
(6) Busy calls	15-20%	15-20%
(7) No answer	4-7%	4-7%

The loss caused by busy calls is rather important and is a consequence of the flat rate system. There are at Amsterdam many business connections with over 100 calls a day. This is one of the greatest evils with which the traffic office has to contend, and though overloading the line is forbidden in the service regulations the only way to deal effectively with the subscriber is to convince him that he is wrong.

As a result of test calls, which are made extensively every day, it is clear that the probability of finding a line busy is much less than would be gathered from the number of busy calls recorded in regular service. It is only one third. This means that as an average the subscriber, finding a line busy, calls three times while the desired number is engaged. This could be avoided by waiting about a minute after a busy call. Something similar occurs in the case of no answer calls, where also the call is repeated several times. This is very difficult to counteract, but very often the "no answer" is due to poor service at the called subscribers' telephone, sometimes arising from inadequate P.B.X. equipment. There is a fertile territory for the activity of the traffic office by working in conjunction with the installing department. The public observes action of this kind from a public service at first with reluctance, then with a certain kind of surprise, but finally with appreciation for the results obtained.

(4) *Checking up traffic data as to constancy.*

Out of the mass of scientific material compiled by the traffic office during the two or three years it has been working, some figures will be taken to show whether the data which are ordinarily used as a basis for the planning of telephone systems and exchanges are really constant. To what extent do they vary?

In Table II. are reproduced the following data relating to a semi-automatic office (C.B.4) and a full automatic office (C.B.5), covering the year 1925 and calculated *for the busy hour* (10-11 a.m.) as an average per month :—

(1) Average load in T.C. on 1st G.S.
(2) Maximum load in T.C. on 1st G.S.
(3) Minimum load in T.C. on 1st G.S.
(4) Maximum number of 1st G.S. simultaneously engaged.
(5) Traffic loss in T.C.
(6) Concentration, viz., the proportion between busy hour T.C. and total T.C. in the day period (9 a.m. to 5 p.m.).

The concentration is extremely constant even when the daily records are compared (ordinarily concentration is expressed as a fraction of the 24-hour traffic, but the figure is also constant). The average duration of a call depends a little upon the traffic loss, but proves to be fairly constant. Figures are respectively :—

C.B.2—Full automatic suburban exchange	95 sec.
C.B.3—Full automatic business exchange	100 ,,

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* S.A. = *Semi-automatic offices.*
F.A = *Full automatic offices.*

C.B.4—Semi-automatic business exchange	100 sec.
C.B.5—Full automatic residence and small business	85 ,,

The duration of a conversation (that is an effective call) is 1.25 times the duration of an average call, being about 120 seconds. The average day calling rate per line during week-day for the year 1925 is as follows:—

C.B.2 = 12.3. C.B.3 = 14.8, C.B.4 = 15.0, C.B.5 = 13.5, C.B.6 = 13.2, and for the system as a whole 13.9.

B.—TRAFFIC OF THE SUBSCRIBERS' LINES INDIVIDUALLY.

(1) *Distribution of the traffic.*

The distribution of the traffic flow in the different channels is one of the most important factors in automatics. All calculations are made up on averages, but an average has only a meaning for a large group of equivalent values and quantities. The smaller the group and the greater the difference between the values or quantities mutually, the less reliable will be a calculation based on averages. Part of the task of the traffic office is to keep up as well as possible the averages provided for in the number of switches installed, and the only way to do so is to stimulate the most equal distribution of traffic in all channels.

One of the most effective means of getting an equal distribution of traffic in the groups is in the allotting of subscribers' numbers. When the spare numbers are equally distributed over the groups, the right choice of the number for each new subscriber allows the regulation of the traffic in the group.

For that reason the determination of new subscribers' numbers is made by the traffic office with regard to outgoing traffic from the subscriber. The permanent traffic measurement on the 1st G.S. determines which group of 2000 lines first must be taken into consideration to take new numbers. The periodical measurements of the final selector groups shows which is the best as to incoming traffic (to the subscriber). For this reason the results relating to final selector groups are recorded in a card system showing in a concise manner the number of lines connected to this group, the average load (T.C.) and the maximum load during the busy hour. Each group has a card and on its rear side are marked the space numbers. The cards are arranged on the visible index method (Cardex system), so that the necessary data can be found without removing a card. The group being determined, the right number is found with the aid of the rear side of the card. Fig. 5 shows the method of assembling the cards in the drawers of the Cardex cabinet with the guide signals. Every ten cards of final selector groups are separated by a yellow card recording the traffic on the 3rd G.S. leading thereto.

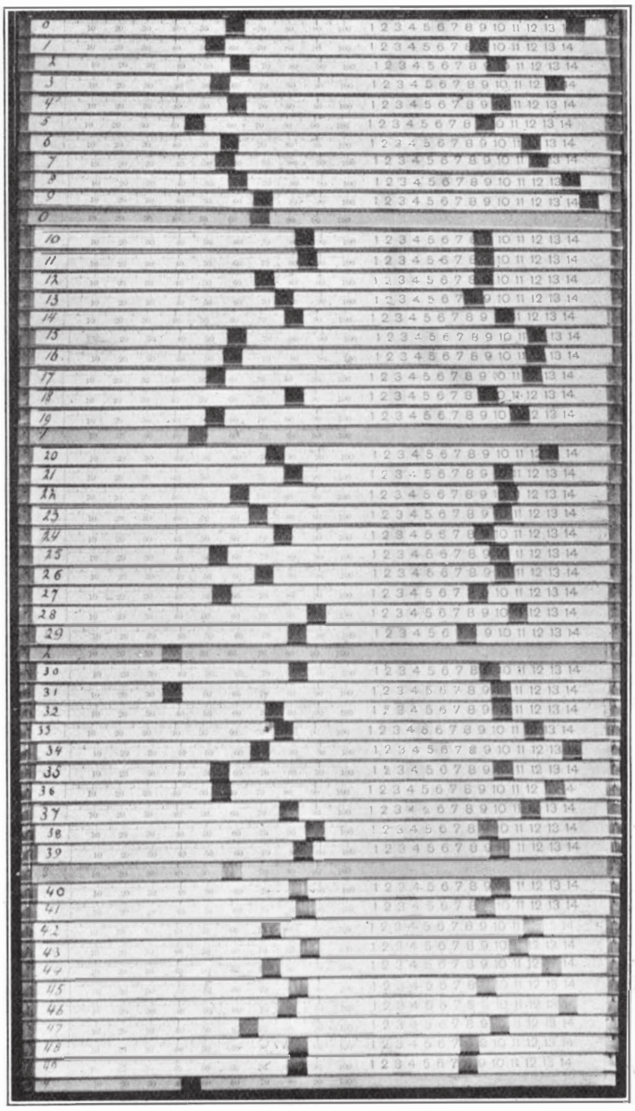

FIG. 5.—DRAWER OF CARD CABINET WITH CARDS AND GUIDE SIGNALS.

It will be evident that for the right application of the method the traffic of each new subscriber must be estimated. This demands a good deal of practice and special records are kept for this purpose.

There is a second method of regulating traffic, *i.e.*, the application of auxiliary line finders on P.B.X. lines. By means of these some overloaded group can be relieved at the expense of underloaded ones. All the numbers of the same exchange can be jumpered to a call number on which the auxiliary line finder is working through a special intermediate distributing device.

The traffic office has to supervise the use of those extra line finders, for which a supplementary fee is charged to the subscriber.

As a proof of the efficacy of the working methods of the traffic office it is stated that in 1924 there were on C.B.4 147 hours in which the 1st G.S. had been overloaded and only 24 in 1926. In 1924 there were, in the same exchange, 43 final selector groups that were overloaded in the busy hour to the extent of 60 T.C. hours; in 1924, 31 to the extent of 30 T.C. hours.

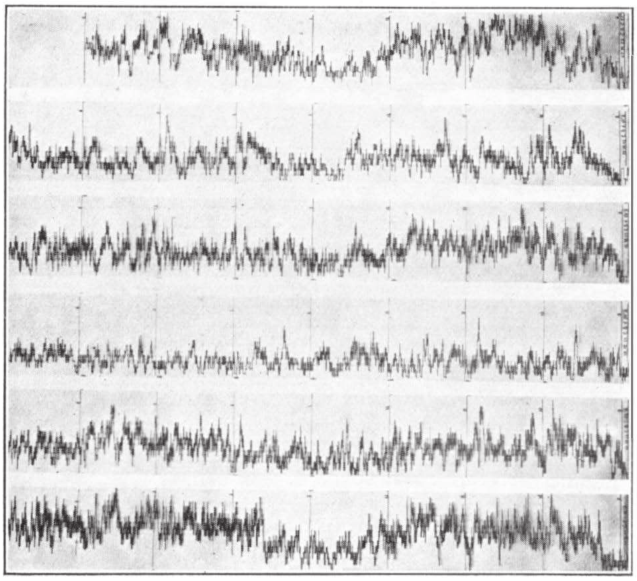

FIG. 6.—GRAPHS OF LINE-FINDER GROUPS.

Fig. **6** finally shows some traffic curves of 100 line final selector groups.

(2) *Quality of the service.*

In all business continuous controlling of the product will be necessary to reveal faults and to detect their causes. For that reason quality must be checked by a standard and all the differences must be explained. Waiting till complaints arise means losing one of the most valuable assets a public service can have, namely, the confidence of the public. In telephony this is still more true, because the manner of acting of the public, who actively participate in the functions of the service, nearly always accentuates every decrease in its quality, giving to all faults the character of a cumulative evil. When, for instance, some irregular loss of traffic appears, the number of calls increases rapidly, increasing the loss again, and so on. Should in this way the critical point* of an automatic exchange be surpassed, the controlling power over the service is lost and most serious and disagreeable surprises are to be expected.

All this has been acknowledged long ago and service tests have existed in telephone practice for a long time. Ordinarily this is performed by listening in to regular connections.

This method has some disadvantages. The controlling officer gets all sorts and conditions of calls and connections mixed up, such as subscribers who make a regular use of their set and children playing with the apparatus, calls from and to lines where some trouble exists, where for some reason or another calls are not answered, or where attention to the telephone is bad.

Mistakes of the public, whether of the calling or the called subscriber, and faults in the apparatus and on the lines cannot be distinguished from real traffic faults. By this method a survey can be got of the working of the telephone system as a whole, but not of the service that is given.

Secondly, it is difficult to detect technical faults because the collaboration of the subscriber is wanted.

In the third place, this method of testing occupies much time, so that only a restricted number of calls can be observed, and at the same time it requires a highly trained officer who must be able to distinguish and to analyse all the cases he will observe, and, last of all, it is not desirable to listen in to connections when it can be avoided.

The manner just described is derived from the practice of manual systems where, for obvious reasons, no other method would be practicable, but in automatic systems it is preferable to choose another way.

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* *I.P.O.E.E.J., Vol.* 19, *Part* 2, *July*, 1926, *p.* 167.

At Amsterdam service tests are made as follows:—

An experienced officer makes, during the busy hour, a great number of test calls, with carefully overhauled standard sets, *from* numbers in a group highly loaded with outgoing traffic *to* numbers in a group heavily loaded with incoming traffic (seen from the subscribers' side). The sets can be continuously changed from one group to the other, so that connections cross the system in all possible directions.

The following are observed:—

- (*a*) Waiting time, S.A. exchanges.
- (*b*) Service of the operator, S. A. exchanges.
- (*c*) Faults.
- (*d*) Ringing signal (both incoming and control on caller's box).
- (*e*) Wrong connections and the reason for the failure.

The cause of faults and wrong connections can be found because the controlling officer has both sets in front of him, so that he can keep every connection in the position in which the fault occurs.

It will be obvious that in this way a record is made of the service afforded under the most unfavourable conditions, independent however of faults and mistakes due to the subscriber, his line and the apparatus. It may be presumed that an average subscriber under normal conditions will experience a more favourable result.

Every day 100 test calls are made in about 60 minutes for semi-automatic and in about 15 minutes for full automatic exchanges. The results are summarised in monthly records, which are compiled from year to year. In Table III. are reproduced the results for two consecutive periods running from July to July. In this way the effect of exchange trouble is determined.

To get an idea of the working manner of the called subscriber the test calls are sometimes altered in such a way that instead of the second standard set a certain series of subscribers is called up.

Besides the data mentioned above, the character of which however is slightly changed, are found:—

- (*f*) Time that elapses between first calling signal and the moment the subscriber answers.
- (*g*) The probability of busy calls.
- (*h*) The probability of no answer within 60 seconds.
- (*i*) Fault and mistakes owing to the called subscriber's lines.

This opportunity is utilised to ask the subscriber his opinion of the service, but complaints are seldom raised in this way. The method, however, is rather dangerous and cannot be recommended when the service is generally poor. The results of the second class of test calls, which are only made at long intervals because they take too much time (2 hours for 100 calls) are:—

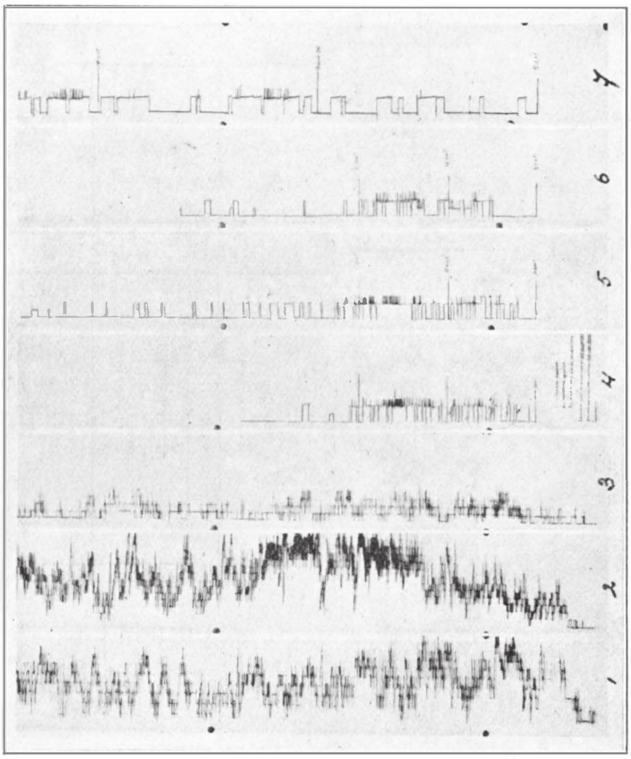


FIG. 7.—OVERLOADED LINES.

A. 8930 lines on C.B.2 (residence exchange).

(*f*)	Waiting time till subscriber answers	10.9 sec.
(*g*)	Called line busy	4.17%
(*h*)	No answer within 60 sec....	12.7 %*

* *This is extremely high because the tests are made during the summer season when many people are out of town.*

(*j*) Apparatus disconnected by the subscriber	0.7 %
(*k*) Sundries	0.27%

B. 7927 lines on C.B.4) business exchange):

(*f*) Waiting time till subscriber answers	8.8 sec.
(*g*) Called line busy	8.35%
(*h*) No answer within 60 sec....	3.87%
(*j*) Miscellaneous faults, the connection, however, coming through	0.8 %

(3) *The investigation of the traffic on particular lines.*

This affords the opportunity to study the traffic not only from a management point of view, but also from the subscribers' side. There are several reasons for making an examination on a particular line:—

(*a*) To collect statistical material in order to make a classification of subscribers in relation to the kind of traffic they desire. This more or less scientific investigation is only done when no urgent work is on hand.

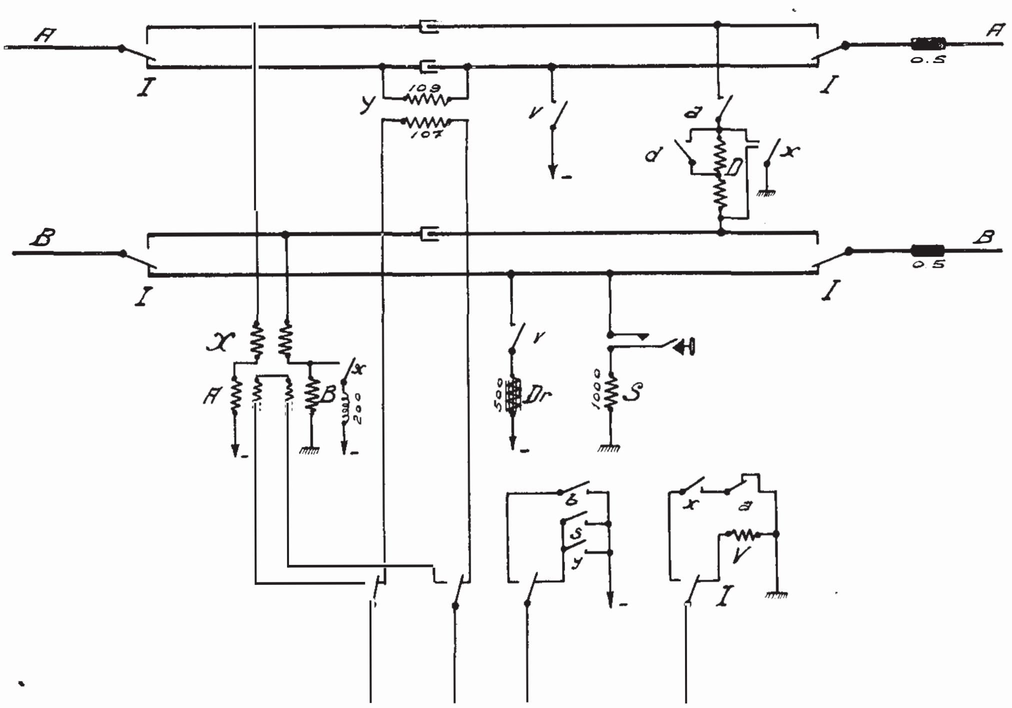


Fig. 8.—Repeater Set to Control Circuit.

The only element lacking in this way of testing the service is the performance of the calling subscriber. Here, however, little can be learned from peg tests. The faults the calling subscriber makes can be occasional or pathological, and it is necessary to determine which. This can only be done by investigating the traffic of a particular line. This is dealt with in the next paragraph. The data recorded by this investigation complete those extracted from the service tests described above.

(*b*) To get the necessary data for proposing to the subscriber the organisation or re-organisation of his telephone traffic. This is only done for the sake of large subscribers, such as banks, important business houses, department stores, brokers, etc. Sometimes the investigation is started on the initiative of the traffic office, sometimes, and this occurs more and more frequently, at the request of the subscriber.

(*c*) To detect traffic faults and to search for overloaded lines. An indication of this is mostly found in the records of the final selector groups. It can be seen immediately from the curve when there is an overloaded line in the group, as might be shown by Fig. **7**, curves No. 1 and 2, the first being normal, the second containing the overloaded line. To persuade the subscriber the curves of Fig. **7**, No. 3-7, are taken, in which the number of busy calls can be easily detected from the dashes on the top of the traffic curve. There are other indications inducing a search for overloaded lines, as for instance, complaints from subscribers or staff. Another reason for taking a line under control is the suspicion that the apparatus is not correctly used. There are many people who dial a wrong number and don't say a word when they discover their mistake. This raises complaints from the wrongly called subscriber to the trouble service, resulting in an unnecessary investigation.

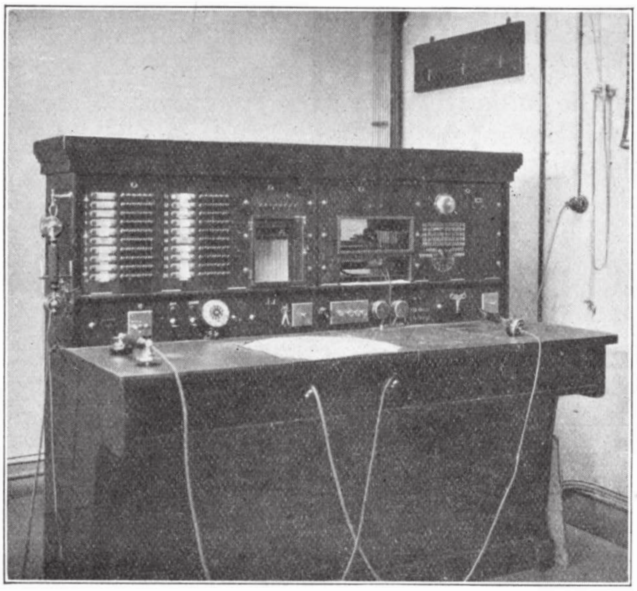


Fig. 9.—Control Desk.

(*d*) In the last resort the traffic office takes a line under control when neither the trouble service nor the repair staff has been able to get rid of a trouble of which the subscriber repeatedly complains. It may be very difficult to distinguish a technical trouble from a traffic fault due to one subscriber or the other, and this can only be determined by permanent control of the line.

(*e*) The last reason for controlling a particular line is to restrain an evil that has very much increased since the introduction of the automatic system, viz., subscribers calling up numbers for annoyance or insult, or to blockade the line.

All data collected from controlling particular lines are kept in a special record containing a mass of useful information on the working of the service as a whole.

Finally follows a short description of the means used by the traffic office for the work mentioned above.

Every line of the system can be connected to a control desk by means of a special repeater set on the M.D.F. when the lines are plugged in the same way as for trouble investigation.

Fig. **8** shows the circuit of the repeater and Fig. **9** a front view of the desk.

The desk is equipped with 20 control lines running to the M.D.F. in the different exchanges; each of these lines contains 5 push-buttons, a calling lamp, which lights as soon as the subscriber takes off the receiver, and a supervising lamp, which lights when the fifth button is pushed down.

The desk contains further two chronographs each fitted with 8 pens, two recording registers, a telegraphone and some switches to cut in different signals.

The 5 push-buttons fulfil the following functions:—

(1) Listening in.
(2) Speaking.
(3) Cutting in the chronograph.
(4) Cutting in the telegraphone.
(5) Holding up a connection to prevent release of the switches. This is to identify calling subscribers or to determine the switches that have been in action in the case of a fault.

The chronographs run 240 or 1200 m.m. an hour. They record the exact time a call begins or finishes, its duration and, besides, a great deal of useful information which can be seen from the specimen reproduced in Fig. **10**. Explanation is given in the letterpress underneath. These instruments are particularly useful when all the lines of the same subscriber are to be investigated. They show then the distribution of the traffic.

The chronographs procure convincing documents to support negotiations with the subscriber concerning the re-organisation of his traffic.

The telegraphone serves to record conversations; it reproduces later the spoken words.

The recording register is shown in Fig. **11**. It is a combination of a register and a typewriter, and writes down the dialled numbers. It is very useful to find out mistakes made by the subscriber in dialling, to detect a faulty dial, and sometimes is used to register the complete operations of a subscriber's line under observation. Moreover, it furnishes a written document that can be use as a proof.

It will now be understood that the traffic office is a very useful, indeed, an essential part of the organisation in telephone management. It has by no means an easy job, but it pays for itself, while creating and consolidating the confidence of the public in the service which, as in no other business, is so indispensable to the telephone service, the results of which depend entirely upon the trustful collaboration between the subscriber and the management.

C.—THE TRAFFIC IN P.B.X. INSTALLATIONS.

This task lies further in the field which the traffic office has to explore and cannot be started before the confidence of the public has been won and deserved.

The traffic office then begins to act as an advising office for the organisation of internal telephone traffic in large business enterprises. There, too, the interest of both parties is the same. An efficient and good working telephone system in large business houses has a prominent importance for the service as a whole.

The methods of investigating the internal traffic in P.B.X. installations do not differ seriously from those explained above.

The initiative for a closer examination sometimes arises from the subscriber, sometimes from the traffic office.

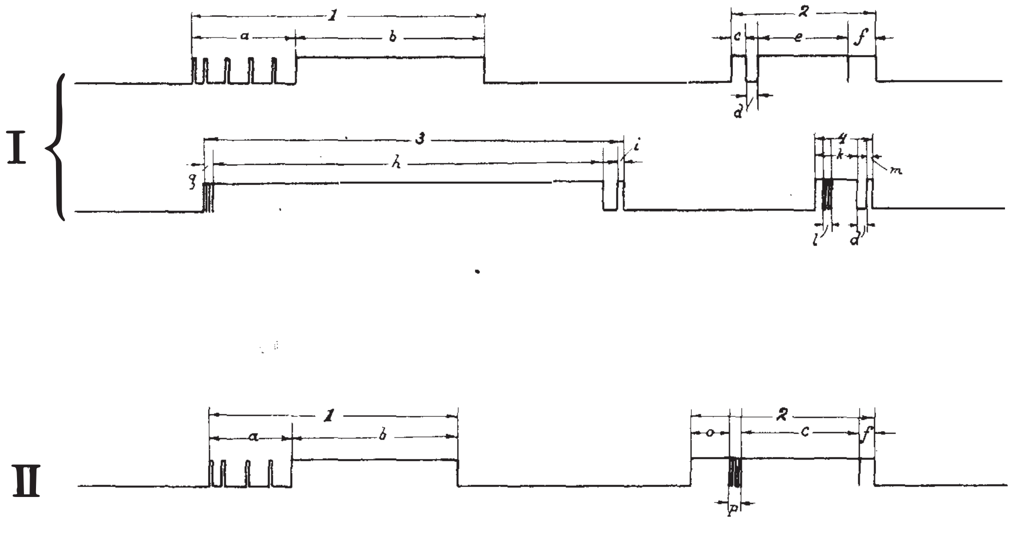


FIG. **10**.—CHRONOGRAPH CURVES.

I. Semi automatic :
  1 Incoming call : *a* ringing signal.
    b conversation.
  2 Outgoing call : *c* waiting time.
    d expedition.
    e conversation.
    f connection not cleared after the end of the conversation.
  3 Toll connection : *g* ringing signal.
    h conversation.
    i report from toll office.
  4 Outgoing busy-call : *k* waiting time.
    l subscriber moves the hookswitch.
    d expedition.
    m subscriber listens to busy-signal.

II. Full-automatic :
  1 Incoming call : *f* see semi-automatic.
  2 Outgoing call : *o* subscriber takes off telephone too early.
    p dialling.
    c see semi-automatic.
    f see semi-automatic.

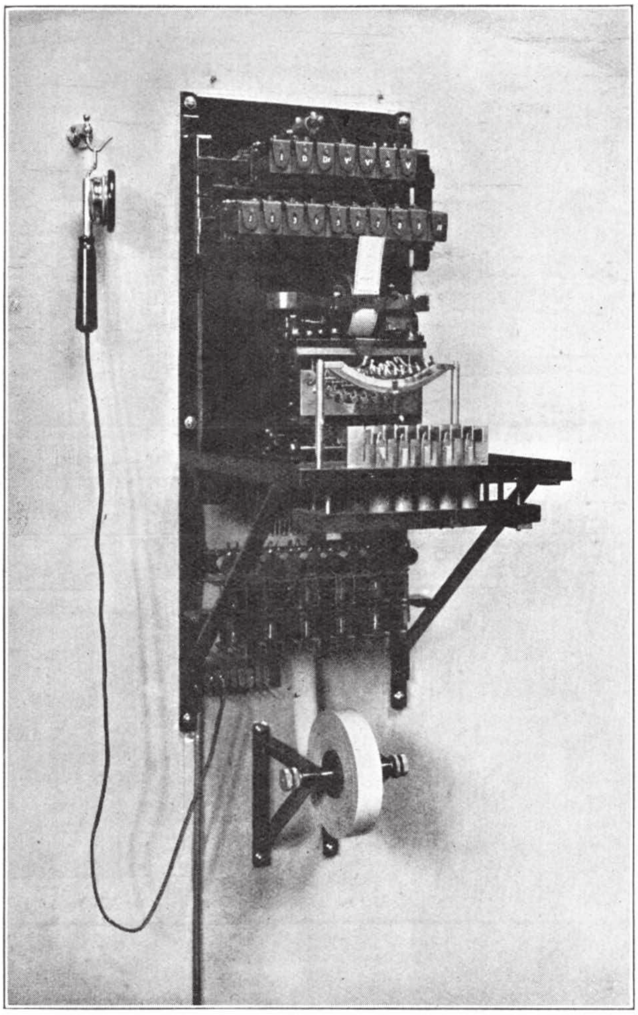


FIG. 11.—RECORDING REGISTER.

In many case the result will be a re-organisation of the P.B.X. installation and the collaboration of the traffic office, the subscriber and the installing department have already given birth to a lot of particular P.B.X. installations designed to give the highest possible efficiency of service. It may be stated in this connection that in Amsterdam no P.B.X. installations are allowed to give through connections to the system except those designed and owned by the municipal telephone service.

The traffic office also, in conjunction with the chief of the operating staff, takes care of the training of the telephonists in the P.B.X. offices.

More and more the public comes to appreciate the work of the traffic office and public opinion proceeds to the conviction that a reasonably operated and well organised internal telephone system is one of the most powerful means of avoiding wast of time and of increasing the efficiency of business organisation.

Then the activity of the traffic office impinges on the territory of propaganda, which surely may not degenerate into a mere advertisement.

The task of a public service is " not to create facilities, but to satisfy a want"*

---

* *Holcombe, " Public Ownership of Telephones on the Continent of Europe," Harvard Economic Studies VI.*, 1911, *p.* 418.

TABLE I.

SCHEDULE OF ACQUAINTANCE FACTORS, MAY. 1926.

	From C.B.2 To				From C.B.3 To				From C.B.4 To				From C.B.5 To			
Hour.	C.B.2	C.B.3	C.B.4	C.B.5	C.B.2	C.B.3	C.B.4	C.B.5	C.B.2	C.B.3	C.B.4	C.B.5	C.B.2	C.B.3	C.B.4	C.B.5
9-10	1.37	0.88	0.89	0.66	0.69	1.2	1.3	0.67	0.54	1.05	1.5	0.72	0.72	0.86	1.10	1.6
10-11	1.57	0.78	0.81	0.73	0.66	1.2	1.2	0.70	0.53	1.06	1.4	0.77	0.79	0.74	1.05	1.9
11-12	1.58	0.78	0.83	0.75	0.71	1.2	1.3	0.67	0.55	1.02	1.3	0.76	0.86	0.75	1.00	1.8
12-1	1.51	0.80	0.8	0.74	0.75	1.1	1.2	0.72	0.63	1.05	1.33	0.79	0.83	0.72	1.00	1.9
1-2	1.42	0.88	0.8	0.70	0.88	1.1	1.1	0.73	0.63	1.08	1.38	0.76	0.81	0.78	1.00	1.8
2-3	1.54	0.83	0.8	0.72	0.81	1.2	1.1	0.71	0.57	1.05	1.35	0.79	0.84	0.74	1.00	1.7
3-4	1.70	0.77	0.8	0.73	0.80	1.2	1.1	0.68	0.61	1.00	1.32	0.77	0.83	0.72	1.00	1.8
4-5	1.70	0.78	0.83	0.76	0.78	1.1	1.2	0.66	0.61	1.00	1.32	0.77	0.86	0.78	1.00	1.71

TABLE II.

TRAFFIC DATA, 1925.

	700 I.G.S. 70% = 490 T.C.	CB4 S.A.					CB5 F.A.				240 I.G.S. 70% = 148 T.C.	
	Av. Load	Max. Load	Min Load	Max. Number I.G.S.	Loss	Conc	Av. Load	Max. Load	Min. Load	Max. Number I.G.S.	Loss	Conc.
Month	TC (BH) 1	TC (BH) 2	TC (BH) 3	4	% 5	% 6	TC (BH) 1	TC (BH) 2	TC (BH) 3	4	% 5	% 6
1	444	495	423	569	22.8	15.8	123	140	103	160	14.6	14.7
2	428	443	428	506	22.1	15.8	120	130	103	168	18.5	14.1
3	419	457	386	527	22.8	15.8	116	125	97	155	9.8	14.8
4	419	457	407	534	22.8	15.8	119	134	97	172	12.8	14.9
5	464	520	422	612	24.9	16.2	126	145	107	182	18.3	14.7
6	444	473	409	554	28.0	15.2	123	138	100	178	15.2	15.0
7	413	447	379	534	22.0	16.2	113	122	93	155	13.5	14.8
8	384	454	344	545	22.4	15.7	105	118	85	148	12.0	14.7
9	446	500	384	578	24.2	15.8	128	143	107	182	13.5	15.1
10	466	507	444	583	28.4	15.8	129	142	112	183	17.0	14.7
11	468	507	451	592	27.0	15.7	131	153	112	181	17.2	14.8
12	468	548	451	602	27.5	15.2	142	161	119	194	15.9	14.8
					24.64	15.75					14.86	14.77

TABLE III.

SERVICE LIST DATA.

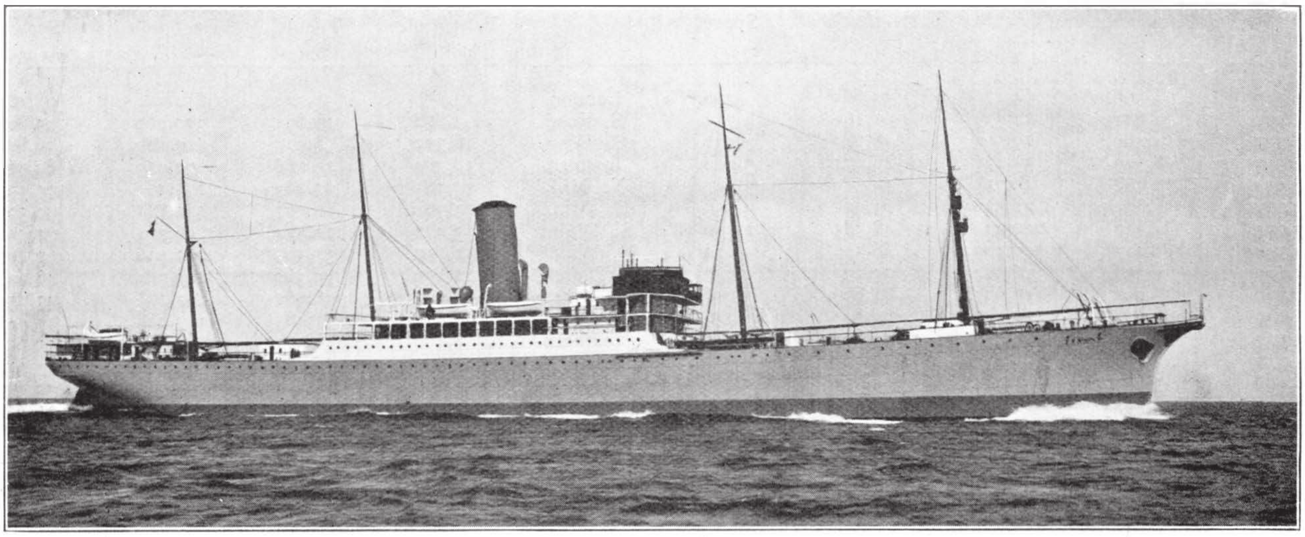
No.	Year.	1.VII. '24—I. VII. 25.		1.VII. 25—1 VII. 26.	
	Type of Exchange.	S.A.	F.A.	S.A.	F.A.
1	Number of test calls	24,291	34,726	14,980	20,837
2	Average waiting time sec. ...	2.1	—	2.1	—
3	Double connection %	0.51	0.1	0.23	0.04
4	Uncompleted connection % ...	1.32	0.1	1.33	0.05
5	Wrong number %	1.71	0.01	1.15	0.01
6	(3—5) Total %	3.54	0.21	2.71	0.1

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DECEMBER, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
518,347	566	4,172	53,661	408	London	23,280	58,721	1,852,442	93,189
63,161	1,881	21,534	61,191	1,734	S. East	3,868	39,891	139,060	15,808
68,333	4,466	29,062	48,627	2,437	S. West	16,302	8,015	120,280	56,802
52,553	8,320	33,127	46,271	3,202	Eastern	18,364	29,266	77,083	82,911
86,091	8,668	42,725	54,529	3,647	N. Mid.	22,681	43,185	179,579	124,232
65,723	4,802	28,549	63,927	3,950	S. Mid.	12,901	19,207	131,891	90,572
53,050	4,827	29,339	48,585	2,150	S. Wales	5,472	22,324	96,561	72,591
90,732	8,215	25,100	46,334	5,072	N. Wales	12,759	37,503	202,756	61,497
141,641	1,576	16,974	42,191	3,096	S. Lancs.	12,470	75,366	423,782	46,900
83,890	6,003	29,937	43,676	3,626	N. East	10,170	38,961	192,248	43,850
56,636	3,648	24,206	35,841	1,746	N. West	8,644	31,485	137,224	37,340
42,737	2,302	15,755	23,404	2,611	Northern	4,498	10,571	85,611	55,053
19,457	4,779	6,535	12,778	317	Ireland N.	140	263	37,417	717
59,006	5,337	23,937	35,172	1,258	Scot. East	2,676	9,165	133,021	50,573
78,443	7,333	24,126	40,937	892	Scot. West	12,176	24,186	204,961	35,479
1,479,800	72,723	355,078	657,124	36,146	Totals.	166,401	448,109	4,013,916	867,514
1,447,128	73,169	352,254	649,543	34,814	Figures at 30th Sept., 1926.	160,895	437,757	3,810,671	805,738

THE PACIFIC CABLE BOARD'S CABLE—BAMFIELD (VANCOUVER)-FANNING ISLAND.



C.S. " Dominia " of the T.C. and M. Co.

THE completion of the duplication of the Pacific Cable Board's Cables between Canada and Australia in November last, with the laying by the C.S. " Dominia " of the Telegraph Construction and Maintenance Co. of a continuously loaded cable in one section of 3,466 nautical miles between Bamfield, Vancouver, and Fanning Island, with the eminently satisfactory results obtained, proves at once the possibility of manufacturing and laying such a cable and also the very superior efficiency of the new over the old type. It is particularly satisfactory also that the cable was not only made in England at the Company's works at Wharf Road and Greenwich, but that the whole of the " Mumetal " alloy (the patent of the Company) for continuously loading the core was made by them at their Bilston (Staffs.) works.

NOTES RE TYPES.

Types 1 and 2—AA3 B.T. and AA2 B.T.
23/1 and 17/2 indicates twenty-three No. 1 iron wires each .300″ in diameter over seventeen No. 2 iron wires each .284″ in diameter.

Types 3 and 4—E3 B.T. and E2 B.T.
17/2 indicates seventeen No. 2 iron wires each .284″ in diameter.

Types 5 and 6—B3 B.T. and B2 B.T
20/6 indicates twenty No. 6 iron wires each .200″ in diameter.

Type 7—D2 B.T.
35/14 (E.W.T.) indicates thirty-five No. 14 steel wires each .083″ in diameter. Each wire separately compounded and taped.

Type 8—D.

20/14 (E.W.T.) indicates twenty No. 14 steel wires each .083″ in diameter. Each wire separately compounded and taped.

One core in the three core types is unloaded.

NOTE.—B.T. indicates that the cores are brass taped for teredo protection.

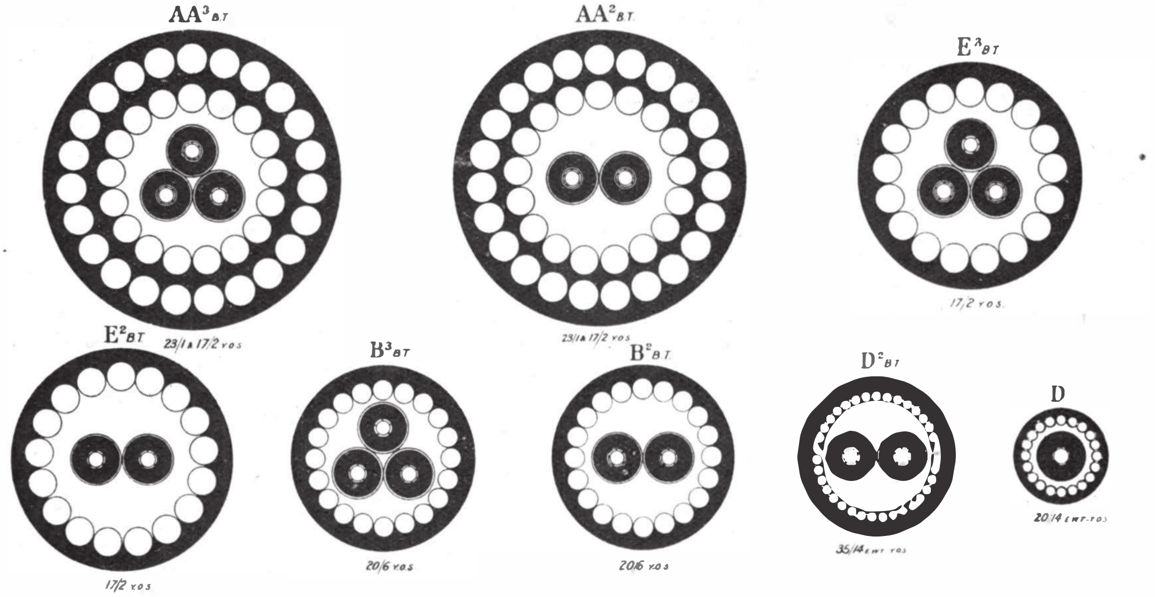
Y.O.S indicates an outer serving of jute yarns.

T.O.S. indicates an outer serving of hessian tape.

The following are the external diameters of these types.

BAMFIELD-FANNING ISLAND CABLE, 1926.

Core $\frac{590}{370}$ lbs. $\frac{\text{CU loaded}}{\text{G. Percha}}$ per N.M. Half full size.



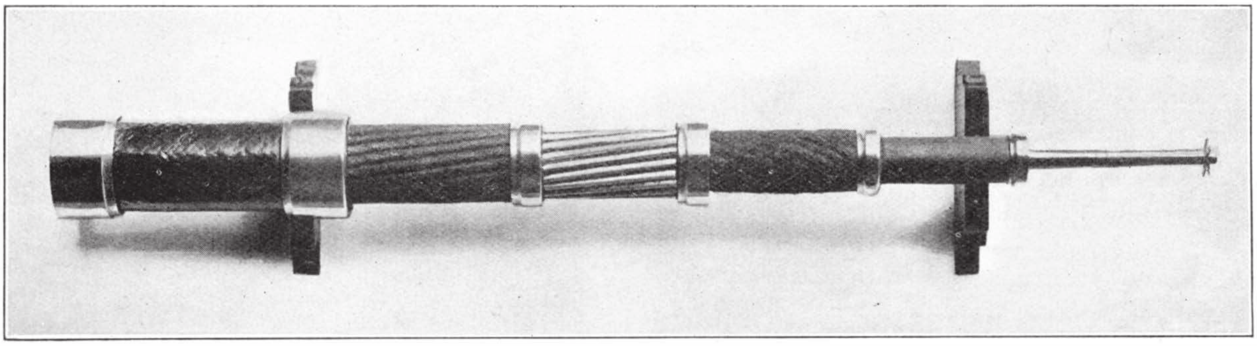
The illustration shows the line core, and also the sending and receiving earths in certain sections.

Type.	Diameter in inches.	Shipping Weight in tons per n.m.
AA3	2.98	33.
AA2	2.92	33.
E3	2.21	15.
E2	2.21	15.
B3	1.835	9.8
B2	1.800	9.4
D2	1.500	4.5
D	0.955	2.1

General Design.—In addition to the usual specification for tests by direct current, a guarantee was required regarding attenuation to alternating current which largely governed the design of the cable.

This guarantee was as follows:—

"The completed cable when laid and throughout the guarantee period shall be capable of transmitting at the rate of 600 letters per minute simplex; the speed shall be calculated on the basis of a minimum received current of 10 R.M.S. microamperes with receiving apparatus of impedance equal to the characteristic im-



TELESCOPIC VIEW OF CABLE SHOWING MAKE-UP.

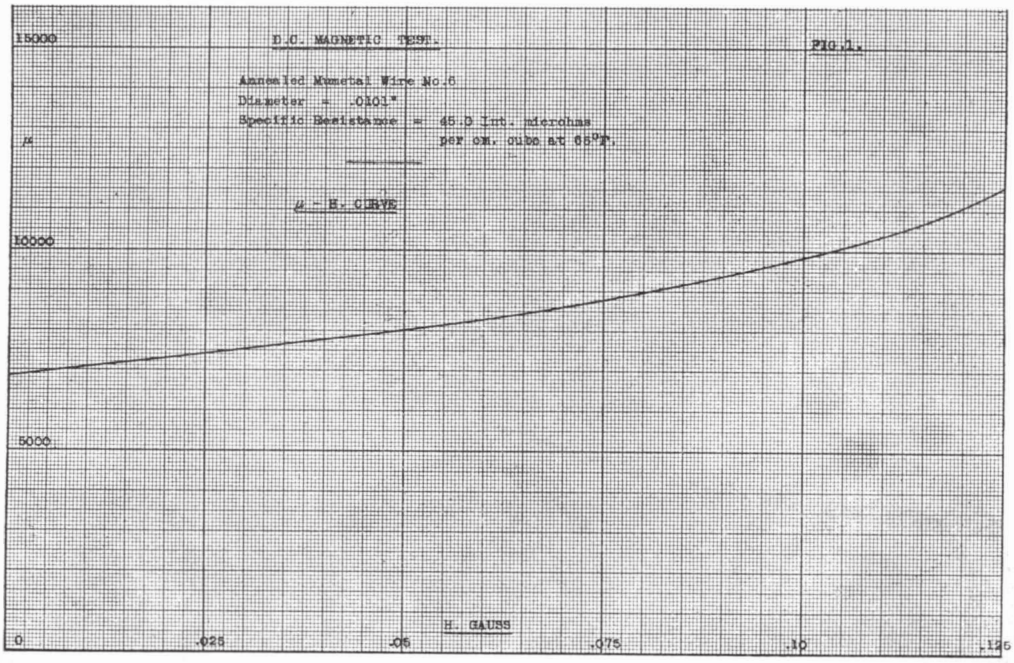
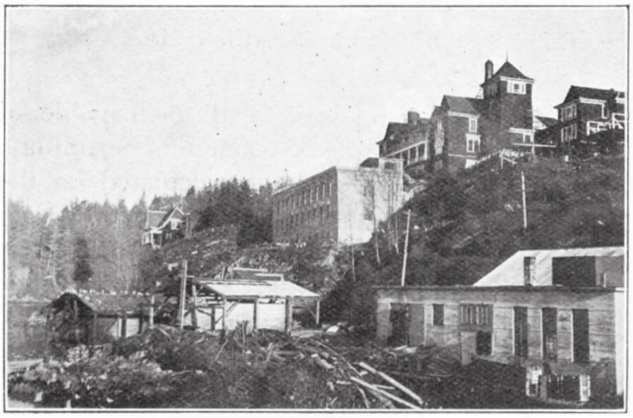


FIG. 1.—μ H CURVE FOR MUMETAL.

pedance of the Cable when sending reversals with 60 D.C. volts at the dot frequency, counting four centre holes per letter."

After a mathematical investigation of alternative designs and the manufacture and test of short specimens, it was decided that the core should be constructed as follows:—



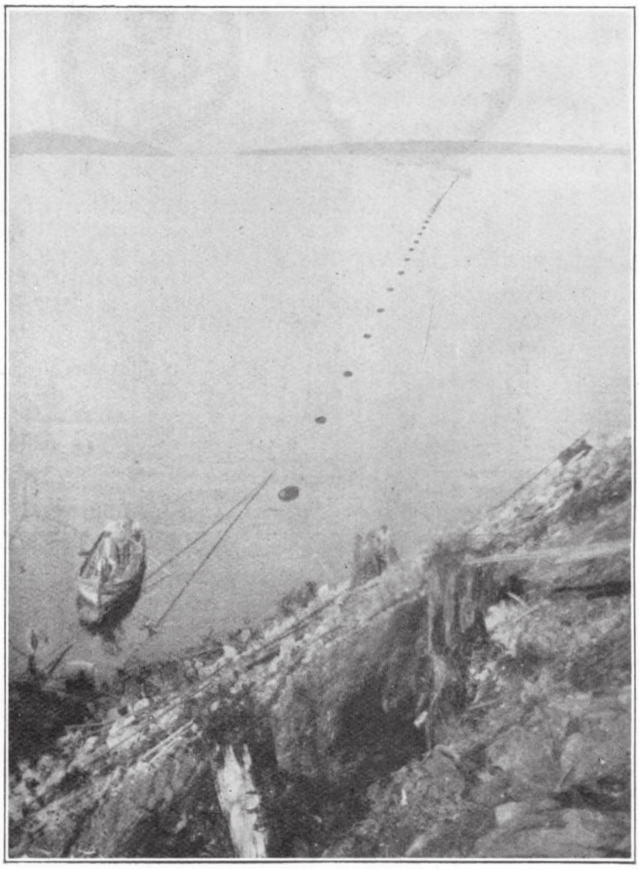
BAMFIELD REPEATER STATION, VANCOUVER.

Copper Conductor.—Central wire of diameter .150 inch surrounded by five tapes each .100 by .016 inch. Weight 590 lbs. per nautical mile.

Loading.—One layer of .010 Mumetal wire. Weight 104 lbs. per n.m. of conductor.

Insulation.—Gutta Percha. Weight 370 lbs. per n.m.

In Fig. 1 is given a typical μ H curve of the Mumetal as used for loading submarine tele-

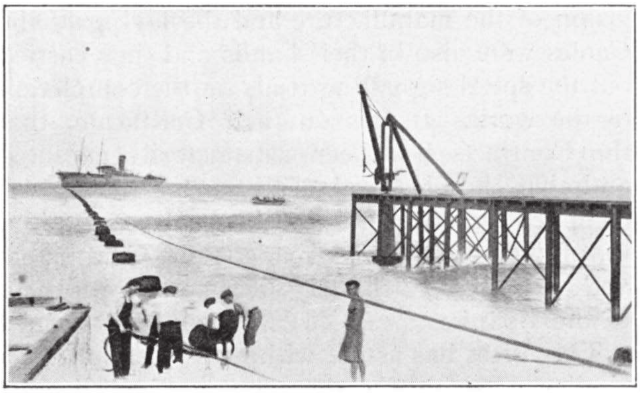


LANDING SHORE END AT BAMFIELD FROM C.S. "DOMINIA," 27TH OCTOBER, 1926.

graph cables. The total length of loading wire in the cable was nearly 250,000 miles.

For the comparatively large sending currents at the ends of the cable the high hysteresis loss accompanying the maximum inductance obtainable made the development of such inductance inadvisable. Owing to the long length of the cable and the specification requirements as to speed of working, it was necessary to keep the direct current resistance of the cable below 2 ohms per n.m., and to ensure that this figure was not greatly exceeded for A.C. at 20 ∼. Special attention was therefore given to the eddy current and hysteresis losses, any undue excess of which would form a large percentage increase on the low total resistance of the cable. The eddy current losses were kept low by the high specific resistance—45 microhms per centimetre cube—of the loading material, while the hysteresis loss was reduced to a minimum by suitable heat treatment and by graduating the inductance of the cable. That is, the inductance of the part near the ends, where the current would be high, was kept to a relatively low figure at which the accompanying loss was low, being increased in steps to a maximum in the centre of the cable. Mean values of inductance obtained are given below.

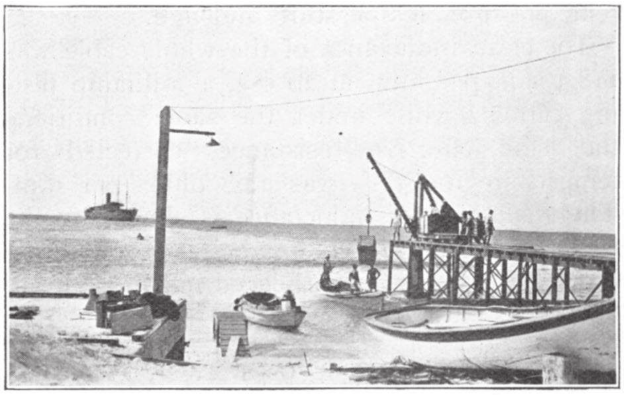
Another View of Bamfield landing.



Landing Shore End at Fanning Island from C.S. "Dominia," 14th November, 1926.

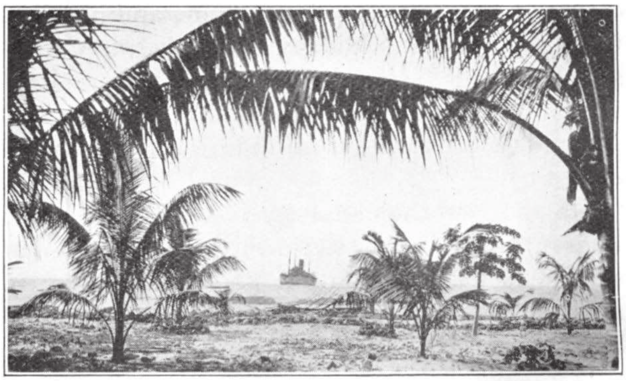
Direct Current Tests.—Each coil (of average length 1$\frac{3}{4}$ n.m.) was tested for conductor resistance, capacity and insulation, at 75°F., 14 days after manufacture. The mean values per n.m. obtained for the whole cable were :—

Conductor Resistance	1.967 Int.	ohms.
Capacity	.3927 ,,	microfarads.
Insulation (after 1 min.)	1110. ,,	megohms.



Instruments being landed at Fanning.

Alternating Current Tests.—For the purpose of ascertaining the inductance and added resistance due to the loading material, each length of core was wound bifilar, thus reducing the geometric inductance of the core (as distinct



The "Dominia" from Fanning Island.

from the inductance added by the loading) to a small and calculable amount. The standard test was taken at 20 ∿ with a testing current of 1 m.a., but a test was also taken at 20 ∿ with 100 m.a. to observe the increase in hysteresis loss for this current.

The leakance of the core was observed by tests at 1000 ∿ at 75°F. on selected short lengths, and from time to time determinations were made of the variation of each of the primary constants with frequency, testing current, pressure, temperature and age.

The mean inductance of the whole cable was 118.3 m.h. per n.m. at 20 ∿, 1 milliamp testing current, while under the same conditions the mean effective resistance, corrected for temperature to 75°F. was 2.08 ohms per n.m. The graduation of inductance is shown by the following table, the sections being given in the order in which they were placed in the cable —

Section No.	Approx. length n.m.s	Average inductance m.h. per n.m.
Shore end	750	106.
A	250	110.
G	250	122.
C	250	129
D E	500	144.
F	250	137.
B	250	123.
H	250	110.
Shore end	750	106.

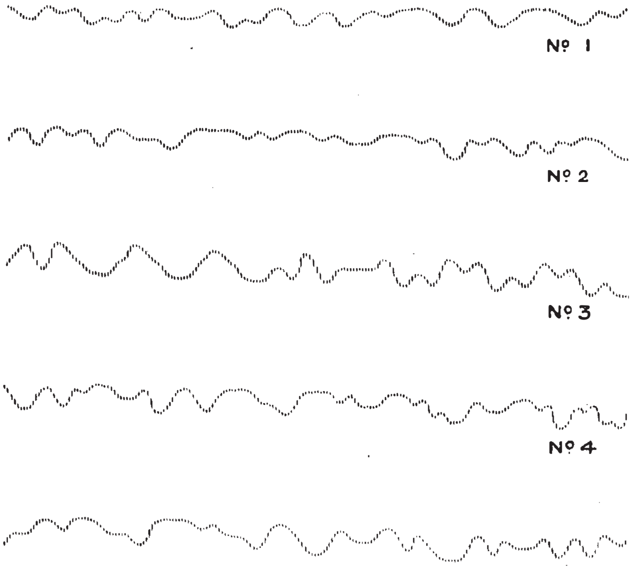
At 1000 ∿, 75°F. the mean leakance on test pieces was 14.4 micromhos. per n.m. and the mean capacity was .382 microfarads.

The original Bamfield-Fanning Cable, having a core of 600 lbs. copper per n.m. and 340 lbs. G.P. per n.m. was laid by the Telegraph Construction and Maintenance Co. in 1902. It is still in continual use, working at a duplex speed of about 270 letters per minute, *i.e.,* 135 l.p.m. each way.

On the new cable the received current under guarantee conditions was nearly five times that specified, while the speed on the basis of 10 microamps received current exceeded 1000 l.p.m.

We give below specimens of messages received at various speeds. The limit of legibility is not reached until a speed considerably above the 1200 l.p.m.

Specimen Signals received over Bamfield-Fanning (1926) Cable. Length 3466.51 N.M. Sending with 60 volts.



No. 1	350	l.p.m.	recorder	only.
2	400	,,	,,	,,
3	600	,,	with	amplifier.
4	1000	,,	,,	,,
5	1200	,,	,,	,,

We are indebted to the T.C. and M. Coy. for the information contained in the foregoing description, and for the loan of the photographs. The signal slips were supplied by Messrs. Clark, Forde & Taylor, of 4, Great Winchester Street, E.C., who have been the Board's Consulting Engineers for the last 27 years, and who were the advisers to the Board for this project. They were responsible for the decision to adopt this loaded type of cable and drew up the Contracts and Specifications, which, for the first time with that type of cable, included a guarantee of performance. The selection of routes, the supervision of the manufacture and the laying of the Cables were also in their hands and they carried out the speed signalling trials on the completion of the work. It was on their Certificate, that the Contracts had been satisfactorily executed and that the electrical condition of the Cables complied in every way with the Specification, that full payments were made to the Contractors and the Cables definitely became the property of the Board.

This Firm has acted, with one exception, in a similar capacity for the owners of all loaded cables laid up to the present, including the German Cable between Borkum and the Azores.

SUBMARINE INSULATION WITH SPECIAL REFERENCE TO THE USE OF RUBBER.

By R. R. Williams and A. R. Kemp.
Bell Telephone Laboratories Inc.

IN the Journal of the Franklin Institute for January, 1927 (Vol. 203, No. 1), a long and important article appears under the above heading. The experience gained with the rubber-covered Seattle-Sitka cable is understood to have been unsatisfactory. The authors of the above article have made an exhaustive investigation into the behaviour of rubber under various conditions, particularly those met with in submarine practice, and their results are set forth in the article in considerable detail. Tables of results and charts of electrical and other tests are given and the article will well repay detailed attention by those interested in rubber-covered cables. The following notes have been extracted from it.

Gutta percha (with or without admixture of Balata) is regarded as the only reliable material for submarine insulation. High cost of these materials constitutes a handicap on the industry. The only reasonable prospect among existing materials as a substitute for gutta percha or balata appears to be some form of rubber. Examination of samples of the Seattle-Sitka cable, which had lain some sixteen years or more at sea-bottom, has shown that the rubber insulation is still in an excellent state of preservation in respect to its mechanical characteristics (N.B.—This cable was replaced by a Gutta Percha cable last year). However, rubber has some distinct technical limitations which will be discussed later. As is well known, rubber may be more fully plasticised by mixing with it a solid material in a finely divided condition. In order, however, to attain the maximum toughness it is necessary to incorporate sulphur in the mixture and after forming the insulation in place to vulcanize it by heating, usually at 120°C. to 150°C. From the standpoint of permanence of mechanical and electrical characteristics, gutta percha has proved to be nearly ideal, there being practically no change over a period of fifty years at sea-bottom. All available evidence indicates that vulcanized rubber as heretofore manufactured is equally permanent in its mechanical properties under the same conditions but is lacking in stability of its electrical properties.

This instability in electrical properties is manifested in rubber-insulated cables principally by slow increase in capacity over periods of years. In some cases the dielectric constant of the insulation has become double what it was at the time of manufacture. The other electrical properties are also adversely affected in some cases. These changes are largely due to penetration of water. The insulation engineer must not count on anything being " water-proof " in the sense of being unaffected electrically by moisture. Rubber insulation shows the same sort of changes in water content and in electrical values with wetting and drying as gutta percha. However, the magnitude of the changes in most rubber insulation is very much larger than in well prepared gutta percha. On a dry basis unfilled vulcanized rubber is comparable with gutta percha in dielectric constant and phase difference angle. On the other hand, after prolonged immersion in water, rubber commonly compares quite unfavourably with gutta percha. In order to evaluate materials for submarine insulation a method was devised to give a reasonably rapid approximation of the effects of sea-bottom conditions on such insulations. Thin sheets of the various materials were prepared and their water content and electrical characteristics measured both dry and after various periods of immersion in aqueous media. Also a method of electrically testing sheets was developed and applied quite generally, as some correlation of water content and electrical characteristics was to be anticipated. Essentially the method consists of placing a sheet of rubber of known thickness between two accurately plane-surfaced steel electrodes and measuring the capacity and conductance at 1000 c.p.s. with a suitable bridge. Direct current insulation resistance is also measured with a sensitive galvanometer. The changes in weight of the rubber sheets are noted as an index of the water content from time to time. A system carefully standardized so as to be uniform is necessary for surface cleaning and drying to avoid anomalies due to surface contact between electrode and insulating material. The sheets are rinsed with distilled water, blotted with filter paper, exposed to a current of dry air for one minute and immediately placed between the electrodes, readings being taken after one minute. The fact worthy of first mention is that the amount of water absorbed by sheets of uniform thickness of a given material depends on the salt content of the water in which the sample is immersed. The results of observations suggested that water absorption is dependent on the osmotic pressure of the external solution and led to the corollary proposition that the amount of water absorbed is also controlled in part by the molecular concentration of water-soluble substances contained within the mass, *i.e.*, the osmotic pressure of the internal solution. This viewpoint can be readily illustrated by milling into a rubber mass a small amount of salt and immersing the sheet in fresh water. In a few weeks the position of the salt particles is marked by water-filled blisters which protrude from the surfaces of the rubber and often burst from the internal osmotic pressure which is developed. The effect of the water-soluble constituents normally present in rubber is also to cause increased water absorption, but in this case, on account of the higher degree of dispersion, no visible blisters appear. Removal of water-soluble substances, especially of chrystalloidal character, by thorough washing, produces substantial reduction in the water absorption. Soft vulcanized rubber shows this osmotic effect as markedly as raw rubber.

It will be recalled that fillers are required to give the plasticity necessary to good extrusion of rubber. It is a well known fact that fineness of fillers increases the mechanical strength of rubber compounds. Fineness of fillers might be expected to increase water absorption and decrease electrical stability in water because the area of interface between rubber and filler increases with increasing fineness. The results obtained with silica show that this is true. In many filled rubbers this interface appears to be the greatest source of electrical weakness. Certainly the adhesion of rubber to mineral particles is commonly very poor. Whether or not actual adhesion occurs between rubber and filler particles and adsorbed gas film on the surface of filler particles might have an important influence on the volume of interfacial voids. Experience with scores of rubber compounds seems to show a relationship between the amount of adsorbed gas per unit surface of fillers and the changes which rubber compounds containing the fillers show on prolonged immersion in water. The case of zinc oxide is especially interesting. Its particle size is very small and the surface per gramme much higher than that of any other filler studied.

Yet the gas adsorbed per unit area of surface is of a lower order than that of other fillers, and in spite of its fineness zinc oxide produces rubber compounds of maximum electrical stability on immersion in water. Other factors of course may be responsible in whole or in part for this result. Among varieties of silica of equal fineness those which adsorb the least gas are those which produce the most stable compounds.

The influence of gas on adhesion is of less importance in the case of organic fillers. Although the gas adsorbed on particles of hard rubber dust (note, ebonite is known as hard rubber in America) has not been studied, apparently adsorbed gases do not play an important rôle in the case of this filler, as numerous attempts to improve its compounds with rubber by mastication in vacuum have not given the slightest evidence of benefit. Probably this filler is sufficiently plastic at the temperature of vulcanization, so that any gases adsorbed at the surfaces of the original particle distribute themselves throughout the particle. If this takes place no interference with the wetting of the particle of the rubber magma would be expected.

The absorption of water by rubber is attended by an increase in dielectric constant. A similar change is observable in filled rubbers. In general the leakance also rises with water content and the insulation resistance declines. These changes in ordinary commercial rubbers are often extremely large, but in material properly treated to reduce water absorption are comparable with those occurring in gutta percha.

The influence of the factors controlling the dielectric constants of rubber compounds have been evaluated for practical purposes in a fairly consistent though far from mathematical manner. This is less true of the factors controlling phase angle. Fortunately, rubber compounds which exhibit a satisfactory degree of stability of dielectric constant are usually satisfactory as to phase angle as far as our experience extends.

The Authors' summary is as follows:—

(1) Soft vulcanized rubber, though not well adapted to some of the processes of manufacture of submarine cable, can be so made as to be mechanically and electrically suitable and to withstand the action of sea water in a manner comparable with that of gutta percha over a period of a few years. Whether such rubber will retain these characteristics for decades remains to be demonstrated, but it seems probable that it will.

(2) The principal factor to be controlled in producing this result is the amount of water absorbed by the rubber.

(3) Osmotic pressure of internal and external fluids is of prime importance in governing the in-flow of water into rubber and gutta percha.

(4) Lowered water absorption is achieved by removal of water-soluble matter from the rubber, the choice of an insoluble non-reactive filler of suitable particle size and having a minimum of adsorbed gases or other contamination on its surfaces.

(5) The electrical characteristics of rubber compounds and of gutta percha are clearly related to their water content but are not simple functions of the water content.

(6) It appears that the mode of distribution of water is also extremely important.

(7) Most fillers for rubber compounds are not suitable for submarine insulation, either because of undesirable intrinsic electrical properties or because they are conducive to changes incident to water absorption. Hard rubber dust, silica, and zinc oxide are the best fillers from these standpoints so far as known.

F.L.H.

SOME ASPECTS OF THE ELECTRIC CAPACITY OF TELEPHONE CABLES.

A. Morris, A.R.C.S., D.I.C., Wh.Ex., M.I.E.E.

GENERAL.—Modern developments in long-distance telephonic communication have rendered necessary a more detailed and intimate knowledge of that property of multi-core telephone cables which is known as electric capacity. Such knowledge is necessary to all concerned with the technique of wire telephony, including those engaged upon cable manufacture, since a true conception of this property is the first step towards fulfilling the exacting requirements which need to be met in the factory stage of modern long-distance cables. The full capacity requirements of factory lengths of modern trunk cables were first laid down, as far as the British Post Office is concerned, in Specification 73,U. of January, 1926; Clause 7, Section (*b*) of which reads as follows:—

"In each factory length of cable the average electrostatic capacity of all phantom circuits of each group taken separately shall not differ by more than 5% from the value, which shall be determined by multiplying the actual average pair capacity of that group in the same factory length by the factor 1.62."

This article is directed principally to those aspects of cable capacities which are involved in this clause. Theoretical consideration is given to the subject, supporting data being furnished in the form of test results obtained from representative cables during the last ten years or so. The manufacturing means whereby the specified requirements may be met are outside the scope of the article and no attempt has been made to indicate them. In achieving the desired object it will be necessary to deal with the electric capacities associated with the conductors of telephone cables in some detail. In this connection certain general methods of treatment due to Campbell(1) will be emphasised, the only reason and justification for their re-statement in this article being the author's belief that they are neither very generally known, nor their analytical value fully appreciated.(3)

Direct Capacity Networks.—Consider an electrical system consisting of a number of associated conductors, capable of mutual electric action within their own group, but so isolated from all other conductors as neither to give rise to nor to be subject to external electric action. Each conductor will have a capacity to every other conductor in the group and the whole electrical system may be exactly represented so far as capacity is concerned by a network of condensers. If there are N such conductors, each of which has a terminal, then the total number of condensers connecting such terminals together in pairs will be $N(N-1)/2$. Each condenser will represent what is known as the "direct capacity" between the two conductors whose terminals are thereby connected, the whole arrangement of capacities being referred to as the "equivalent direct capacity network" of the system or group of conductors.(1)

The method of dealing with the interactions between a system of conductors by reference to its equivalent direct impedance or admittance network is of extreme general utility. In the case of problems relating to communication circuits, the method provides a valuable means of analysis and for this reason further consideration will be given to it, in its application to cable circuits. Details will also be given of a theorem(1), (2) and of certain properties(1) relating to direct capacities which permit of calculations being readily effected.

Network transformation theorem.—In considering the effective or resultant capacity (for transmission purposes) of a single circuit AB of a multi-core cable the problem resolves itself into the determination of the magnitude of the single capacity between A and B which will have an exactly equivalent effect, as far as transmission along the circuit AB is concerned, as all the capacities associated with that circuit and with the whole of the remaining wires of the cable. For this purpose it will be necessary to consider the direct capacity network of the whole system of cable conductors and then eliminate all the conductors or terminals except the two under consideration. This may be done by well known methods involving the application of Kirchhoff's Laws and the use of determinants. Such methods effect the elimination of all the necessary terminals simultaneously. Alternatively the effect of all the redundant terminals may be eliminated one at a time by the application of a network transformation theorem,(1) due to Prof. G. A. Campbell, which may be stated thus:—

In any network of conductors, a star of N rays OA,OB,......ON, may be replaced by a mesh of $N(N-1)/2$ conductors, AB,BC,CD,...... etc., joining every pair of the terminals A,B, C,......N (terminal O being thereby eliminated) without affecting, as far as concerns its external reaction upon any other electrical system with which it is associated only by conductive connections through the points A,B,C,......N, the rest of the network. With admittance operators:—

$$AB = (OA.OB)\left[\frac{1}{OA+OB+\dots\dots+ON}\right]$$

$$BC = (OB.OC)\left[\frac{1}{OA+OB+\dots\dots+ON}\right]$$

etc.

With impedance operators:—

$$AB = (OA.OB)\left[\frac{1}{OA}+\frac{1}{OB}+\dots+\frac{1}{ON}\right]$$

$$BC = (OB.OC)\left[\frac{1}{OA}+\frac{1}{OB}+\dots+\frac{1}{ON}\right]$$

This theorem is of such exceptional utility in problems relating to telephonic networks that its method of application will be demonstrated later in reference to the mutual electrostatic capacity of the circuits of a two-pair core of M.T. Cable.

Additive properties of Direct Capacities.—One of the greatest advantages attending the utilisation of direct capacity networks lies in the ease with which the alterations effected in direct capacities by external operations upon the network may be calculated. The above-described transformation theorem is useful for this purpose and when used in conjunction with certain additive properties of direct capacities, constitutes an invaluable analytical process. The additive properties referred to have been stated by Campbell(1) and are quoted below, thus:—

(1) A capacity connected between two terminals of an electrical system adds to any direct capacity existing between such terminals, and is without effect on all other direct capacities.

(2) If the terminals of two distinct electrical systems are connected in pairs, the resulting system is one in which each direct capacity is the sum of the corresponding two direct capacities of the individual systems.

(3) If two terminals of an electrical system

are joined together to form a single terminal, the two direct capacities from the two merged terminals to any third terminal, add together. All other direct capacities remain unchanged, except the direct capacity between the two merged terminals, which becomes a short circuit.

(4) If the terminals of an electrical system are joined together into any number of merged groups, the total direct capacity between any pair of groups remains unchanged, whilst the direct capacities within each group become short circuited.

Equivalent Direct Capacity Network of a Multi-Core Cable.—If a group of N conductors be totally enclosed within an earth-connected conductor, then in addition to the N(N – 1)/2 direct capacities which connect such conductors together in pairs, it is obvious that N further capacities will be brought into existence, since each conductor will have an additional direct capacity to earth. If each of the N conductors is a wire of a multi-core cable and the earth-connected conductor represents the cable sheath, then the equivalent direct capacity network of such a system will be represented by N(N – 1)/2 direct wire-to-wire capacities and N direct wire-to-earth capacities.

Direct Capacity Network of a two-pair Multiple-Twin Core of a Multi-Core Cable.—For the purpose of examining the nature of the mutual reactions arising wholly within a two-pair core, *e.g.*, either the relative effective transmission capacities of its various derived circuits or their mutual interference possibilities, it is necessary to consider the equivalent direct capacity network of such a core. If it existed alone within an earthed sheath, its equivalent network would, according to the foregoing, obviously consist of six direct wire-to-wire capacities and four direct wire-to-earth capacities. In a multi-core cable, however, such a core is associated with a number of other cores which must be given consideration. In dealing with this general case it is convenient to consider in the first instance the equivalent direct capacity network of the whole cable. The core under consideration may then be regarded as consisting of four accessible terminals, the cable sheath as consisting of a single accessible terminal and the remaining (N – 4) wires of the cable as consisting of (N – 4) inaccessible terminals or concealed branch points, subsequently to being eliminated. Elimination of these terminals by the method already indicated will result in the equivalent network of the core, which will consist of ten direct capacities as heretofore, six connecting the wires of the core directly and four connecting the wires to earth. Thus the direct capacity between any two wires is the single capacity which is the exact equivalent of all the other capacities connecting the two wires (or accessible terminals) either directly or *via* the remaining (N – 4) wires (or concealed branch points). The six capacities complying with this definition are the six direct wire-to-wire capacities of the core. The direct capacity between any wire of the core and earth is the single capacity which is the exact equivalent of all the capacities connecting the wire and sheath (both accessible terminals) either directly or *via* the remaining (N – 4) wires (or concealed branch points). The four capacities complying with this definition are the four direct wire-to-earth capacities of the core.

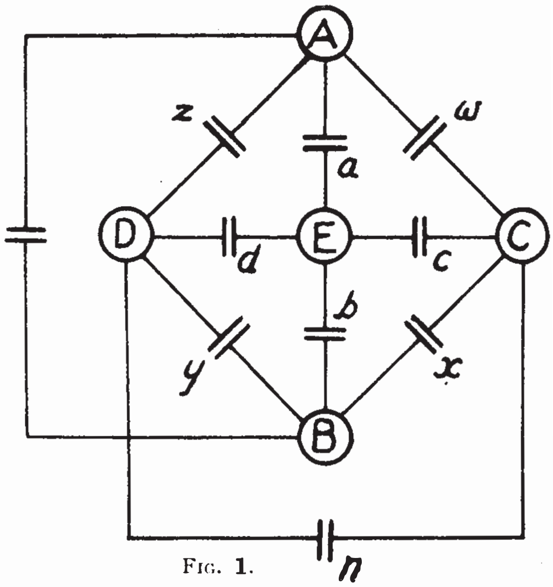


Fig. 1.

Fig. 1 represents diagramatically and symbolically the equivalent direct capacity network or the direct capacity couplings of the conductors of a four-wire core or unit of a lead sheathed cable. A and B form one pair or side circuit, C and D the other pair or side circuit. The cable sheath is assumed to be connected to earth. The component capacities, *w*, *x*, *y*, *z*, *m*, *n*, *a*, *b*, *c* and *d*, the first six being wire-to-wire capcities, and the remaining four wire-to-earth capacities, are the direct capacities of the system defined in accordance with the foregoing.

It will be obvious, from the actual mode of definition, that the magnitudes of these direct capacities when the core exists alone inside the sheath will be different from the magnitudes obtaining when the core—without change of the relative position of its wires—is associated with a number of other cores. Furthermore, the extent of the difference will be accentuated by earth-connecting such associated wires. Table No. II., which gives the results of actual measurements, demonstrates this feature, which will be dealt with at greater length later. In dealing subsequently with the direct capacity networks of individual four-wire units of multi-core cables it will be assumed that the conductors of all cores other than the one under consideration are disconnected from each other and from the lead sheath. Under these conditions the direct capacity between A and C, B and C, B and D, and A and D, which are respectively w, x, y, and z, will be referred to as the direct capacities between wires not in the same pair. The direct capacities between A and B, and C and D are respectively m and n; each will be referred to as the direct wire-to-wire capacity of a pair, a, b, c and d, the capacities of the wires A, B, C and D respectively to the cable sheath—assumed to be earthed—are the direct earth capacities of the wires of the core.

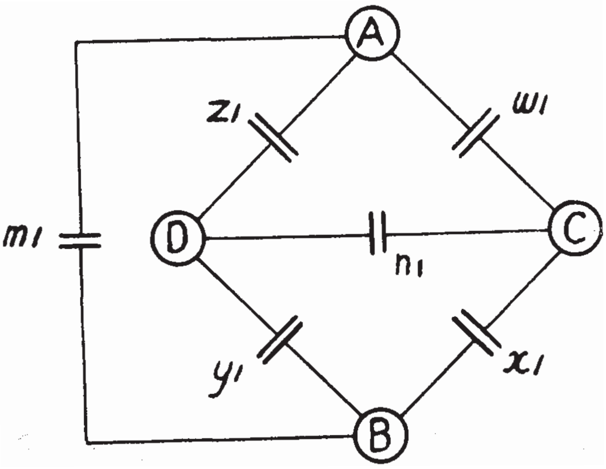


Fig. **2**.

Mutual Electrostatic Capacity of the Circuits of a two-pair Core of Multiple-Twin Cable.—With the direct capacities of the core as represented by the five terminal, ten member mesh of Fig. **1**, the mutual capacity of any of the circuits which may be formed on the core can be readily calculated by the methods which have already been indicated. In illustration of these methods the AB side circuit capacity will now be computed. Thus:—

(1) Referring to Fig. **1**, replace the four ray star EA,EC,EB,ED by the six member mesh AC,CB,BD,DA,AB,CD. The resulting network is shown in Fig. **2**, where:—

$$\left.\begin{array}{l} w_1 = w + ac/\delta_1 \\ x_1 = x + bc/\delta_1 \\ y_1 = y + ba/\delta_1 \\ z_1 = z + ad/\delta_1 \\ m_1 = m + ab/\delta_1 \\ n_1 = n + cd/\delta_1 \\ \delta_1 = a+b+c+d \end{array}\right\}$$

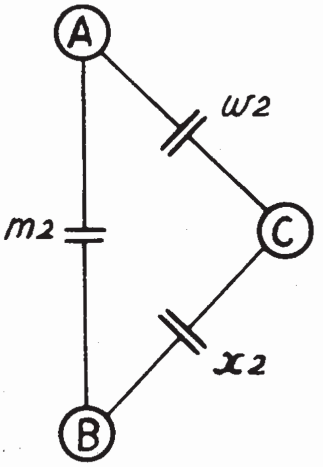


Fig. **3**.

(2) Referring to Fig. **2**, replace the three ray star DA,DC,DB by the three member mesh AC,CB,AB. The resulting network is shown in Fig. **3**, where:—

$$\left.\begin{array}{l} w_2 = w_1 + n_1 z_1/\delta_2 \\ x_2 = x_1 + n_1 y_1/\delta_2 \\ m_2 = m_1 + z_1 y_1/\delta_2 \\ \delta_2 = y_1 + z_1 + n_1 \end{array}\right\}$$

(3) Referring to Fig. **3**, replace the two ray star CA,CB by the single member AB. The result is the single capacity m_3, shown in Fig. **4**, where:—

$$\left.\begin{array}{l} m_3 = m_2 + w_2 x_2/\delta_3 \\ \delta_3 = w_2 + x_2 \end{array}\right\}$$

m_3 is the mutual wire-to-wire electrostatic capacity of the side circuit AB and is exactly analagous to the quantity which is referred to in British Post Office Specification No. 73, as the electrostatic capacity from wire-to-wire of the cable pairs—all other wires of the cable being insulated from each other and from the lead sheath during any measurement which may be made to determine its magnitude.

A similar expression, n_3, may be derived for the mutual wire-to-wire capacity of the CD side circuit. If these results are evaluated in terms of the direct capacities of the core (see Fig. 1), rather lengthy expressions will be obtained. They will be simplified, however, if the core under consideration has some degree of electrical symmetry or balance. Thus if $w = x = y = z$, $a = b$, and $c = d$, then :—

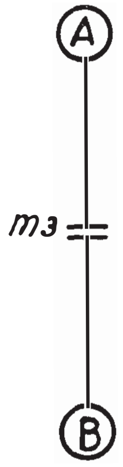


FIG. 4.

$$m_3 = m + w + a/2, \text{ and } n_3 = n + w + c/2.$$

The mutual pair-to-pair capacity of the two-pair superposed or phantom circuit may be calculated in a similar manner. The result for the general case will be $w + x + y + z + [(a + b)(c + d)/(a + b + c + d)]$. For the degree of balance already postulated, this expression will reduce to $4w + 2ac/(a + c)$, which may be written thus :—

$$2\,[(m_3 + n_3)/2 - \{(m + n)/2 - w\} - (a - c)^2/4(a + c)]$$

Since with ordinary construction, the mean direct wire-to-wire capacity of a pair is greater than the direct capacity between wires not in the same pair, it will be evident from the above expression that the mutual pair-to-pair capacity of the phantom circuit of a two-pair core of multiple-twin cable is less than twice the mean mutual wire-to-wire capacity of its associated side circuits.

Relative values of the Wire-to-wire Direct, the Wire-to-earth Direct and the Mutual Capacities of a Balanced Core of Multiple-Twin Cable.—It is often convenient when dealing with the various capacities of a core of commercially manufactured cable to compare each of them with the magnitude of the mutual wire-to-wire capacity of a side circuit of that core. For this purpose each of the direct capacities as well as the phantom circuit capacity is expressed as a fraction of the wire-to-wire mutual capacity. These quantities will subsequently be referred to as the direct and phantom circuit capacity ratios of a core.

In the case of a two-pair core of multiple-twin cable, for which $w = x = y = z$; $a = b = c = d$; and $m = n$, the phantom circuit capacity P will be equal to $2\,[S - (m - w)]$ where S is the mutual capacity of each side circuit. The phantom circuit capacity ratio can accordingly be expressed symbolically as follows, namely :—

$$P/S = 2\,[1 - \{(m - w)/(m + w + a/2)\}]$$

The numerical value of this ratio will depend upon the magnitude of the direct capacity ratios, but since in a multiple-twin unit of normal construction w can never be greater than m, the phantom circuit ratio for such a unit can accordingly never exceed 2. In practice w is always smaller than m and hence the phantom circuit ratio is always less than 2. Values ranging from 1.26 to 1.72 have been observed in practice. Table No. I. gives the average value of this ratio for cores of balanced loading coil section lengths of each of a number of existing cables, manufactured within the last twelve years.

In cable manufacture, where the direct effects of one feature are often masked by the effects of another, or by secondary effects of the former, it is well known that great care needs to be exercised in arriving at definite conclusions as to the exact control imposed by each of the special features embodied in a design. The following statements have accordingly been carefully worded; they give the author's views on the basis of his experience, and do not rule out the possibility of alternative explanations.

If two multiple-twin cables each containing N cores arranged in an exactly similar manner in n layers underneath a lead sheath of internal diameter d, are so constructed as to have exactly the same side circuit mutual capacity value, the direct capacity ratios for the cores, may be quite different in one cable from what they are in the other. This is obviously possible from the form of the expression for mutual wire-to-wire capacity of a side circuit, and is in fact borne out in practice. The fundamental reason for this would appear to lie in the permissible choice during manufacture of the relative tightness of the twinning, quadding and stranding operations, which govern the mean distances separating (1) associated wires of the pairs, (2) associated pairs of the cores, and (3) adjacent cores. The actual twinning and quadding lays, the relative lengths of which are of primary importance from the interference point of view, appear to exercise little effect in normal practice, upon the magnitude of the direct capacity ratios. The choice in tightness of make up, already referred to, is limited in practice by many considerations, but such scope as does exist is sufficient to give rise to noticeable differences in the relative magnitude of the direct capacities obtaining in cables which are nominally of similar design.

For any particular cable of normal manufacture, the mutual electrostatic capacity of the side circuits is the same, excepting for small manufacturing deviations, for all cores contained in the same layer. The direct capacity ratios and in consequence the phantom circuit capacity ratios are also respectively of the same magnitude for such cores. The mean mutual capacity of the side circuits of one layer is usually somewhat different from that in another layer, although modern design and manufacture are conducive to equalisation of the different layers in this respect. For cores contained in different layers the direct capacity ratios are always materially different; thus the direct wire-to-wire capacity ratios are smaller and the direct wire-to-earth capacity ratio is larger for cores situated in the outer layer, than for those nearer the centre of the cable. This is illustrated by the tests of a 176 yard factory length of 60/40 M.T. cable, the results of which are given in Table No. II. The fundamental idea underlying the representation of the four-wire system by its equivalent direct capacity network is probably sufficient to explain this fact.

If during manufacture undue tensions are permitted in the twinning, quadding or stranding operations, crushing of the multiple-twin units either partially or wholly will occur and marked differences in the direct and phantom circuit ratios of the cable cores will arise, not only as between the cores of different layers, but also between cores of the same layer. Thus crushing in the twinning stage, by increasing the m ratio at the expense of the w ratio, will tend to a decrease in the phantom circuit ratio. Crushing in the quadding stage will increase the w ratio, either at the expense of or independently of the m ratio, and so tend to an increase in the phantom circuit ratio.

In the ideal multiple twin cable the cores would be perfectly twinned and quadded. Furthermore, the stranding operations would be performed in such a manner as to ensure that each core occupied (and completely filled) exactly the same amount of space. This latter feature is aimed at in the design and manufacture of modern multiple-twin cables and seems to be an important feature in ensuring stability, *i.e.*, no capacity change during handling. For such a cable the mutual capacity of the side circuits would be the same for each two-pair core (except for the differences imposed by reason of the different lengths of the cores of the various layers) and from the very nature of the direct capacities, their values would regularly and progressively decrease in the case of the wire-to-wire and increase in the case of the wire-to-earth, from the centre layer outwards to the exterior layer. In these circumstances the phantom circuit capacity P, *i.e.*, $2[S-(m-w)]$ (where S is the associated side circuit capacity) of the cores situated in one layer may be different from those situated in some other layer, tending generally to progressively increase from the centre to the outer layer. In this ideal case the same remarks will apply to the phantom circuit capacity ratio of the cores. Such a condition is actually found to exist in practice, in those uncommon instances where the side circuit capacity of the cores is essentially the same in all layers. The test results shown in Table No. II. for a 60/40 M.T. cable, illustrate this feature.

More generally the side circuit capacity differs in different layers and there is accordingly no regular gradation in the values of the direct or phantom circuit capacity ratios from layer to layer. The test results given in Table No. I. for a 96/70 M.T. cable (Example 1) illustrate this point, the phantom circuit capacity ratios being 1.61, 1.59, 1.63 and 1.51 for cores of the centre, first, second and third layers respectively. The example is of further interest on account of the fact that the actual magnitudes of the direct capacities of the cores of the first and third layers are such that their phantom circuit capacities are essentially the same, namely, 0.0949, and 0.0948 micro-farads per mile respectively.

If for the ideal case, the phantom circuit ratios could be determined for the various layers of cables of various sizes and make-up, a criterion for judging this aspect of commercially manufactured cables, which of course fall short of perfection, would be available. The determination of these ratios by calculation would, it is thought, be an extremely complicated operation and has, as far as is known, never been achieved. It is probable that their magnitudes are to some extent dependent upon the gauge of the cable conductor, and it is certain that the type of construction adopted in manufacture materially affects their value. The British Post Office specifies (Specification 73 U. of January, 1926) an average value for this ratio of 1.62, with a permissible tolerance of 5%, *i.e.*, a value ranging from 1.54 to 1.70. This specified value is applied to all multiple-twin cores, independently of their position in the cable.

Effect on the Mutual and Direct Capacities of a single Cable Core, of Earthing the remaining Cable Cores.—Hitherto the direct capacity network of any core of a multi-core cable has been defined on the basis of the conductors of the whole of the remaining cable cores being insulated from each other and from earth. If these conductors, however, are connected to earth, it will be obvious that the direct capacity network of the core under this condition will be quite different, as far as the magnitudes of the direct capacities are concerned. This has already been indicated in the paragraph headed "Direct capacity network of a two-pair core of multiple-twin cable." The original direct wire-to-wire capacities will clearly be reduced by reason of certain of the capacities composing them being diverted to earth, whilst these latter capacities will augment the original direct wire-to-earth capacities. As between the two conditions, the direct wire-to-wire values will be smaller and the direct wire-to-earth values larger when the other cores are earthed, than when they are insulated. This conclusion is borne out by the results of actual measurement.

In regard to the mutual capacities of the pair and phantom circuits, the calculations necessary for the purpose of comparing the values under the two conditions lead to rather lengthy expressions in the general case. If the decrease in the wire-to-wire and the increase in the wire-to-earth components exactly neutralised one another, there would be no change in the mutual capacity values under the two conditions. Careful measurements show that no change does in fact take place.

Table No. II. gives the results of tests on a 2.6 mile length of cable of 60/40 M.T. cable and also a 176 yard length of cable of the same type, but of different manufacture. Figures are given for centre, first and second (or outer) layer cores under "free" and "earthed" condition of the remaining cable cores. Each core was separately insulated under the "free" condition. The constant values of the mutual capacities and the changes in the direct capacities are clearly shown. Tests were also made with the remaining cores bunched together, but insulated from earth. The results obtained have not been tabulated, but whereas the mutual capacities remained constant, the direct capacities were intermediate in value between those quoted for the "free" and "earthed" condition respectively. The table gives the mutual capacity S of the side circuits in micro-farads per mile. The magnitudes of the direct capacities and of the phantom circuit mutual capacity are expressed as fractions or ratios of the relevant side circuit mutual capacity in the manner previously indicated.

This constancy of value of the mutual capacities, irrespective of whether the whole of the remaining wires (including those of the associated pair, in the case of the side circuit capacity) of the cable are insulated (either separately or as a bunch) or earth-connected has an important bearing on "bunched" mutual capacity measurements, during works tests of the circuits of factory lengths of cable.

From consideration of the expressions for the mutual capacities of a side and phantom circuit respectively, it will be evident that the magnitude of the increase in each of the direct wire-to-earth capacities, consequent upon the earthing of the remaining cores, is four times that of the decrease in each of the direct wire-to-wire capacities—at least as far as a balanced core is concerned. Table No. II. demonstrates this feature.

References have been given, wherever possible, to sources of information, the use of which in this article is gratefully acknowledged. The data contained in the Tables has been included by the courtesy of Colonel Purves, Engineer-in-Chief. The author desires especially to tender his thanks to those of his colleagues who have from time to time furnished and discussed with him the results of many tedious and laborious measurements.

TABLE I.

PHANTOM (P) TO SIDE (S) CIRCUIT MUTUAL CAPACITY RATIOS FOR CORES OF M.T. CABLES OF VARIOUS MAKE-UP AND MANUFACTURE.

Cable Type.	Layer.	Example 1.		Example 2.	
		Side circuit capacity.(S) Microfarad per mile.	Ratio P/S.	Side circuit capacity.(S) Microfarad per mile.	Ratio P/S.
2/300 M.T. +	Centre	0.0545	1.57	0.0564	1.50
14/200 M.T. +	1st	0.0572	1.49	0.0655	1.26
12/150 M.T. +	2nd	0.0685	1.47	0.0697	1.51
24/100 M.T.	3rd	0.0579	1.49	0.0575	1.57
24/100 M.T.	Centre	0.0620	1.64		
	1st	0.0619	1.64		
14/100 M.T. + 36/40 M.T.	1st 2nd	0.0619 0.0607	1.53 1.59		
96/70 M.T.	Centre	0.0573	1.61	0.0732	1.39_8
	1st	0.0597	1.59	0.0735	1.39_7
	2nd	0.057	1.63	0.0734	1.39_5
	3rd	0.0628	1.51	0.0701	1.39_1
60/70 M.T.	C & 1st	0.0579	1.60		
	2nd	0.0561	1.72		
160/40 M.T.	C, 1st & 2nd 3rd	0.0598 0.0634	1.50 1.41	0.0598	1.44
	4th	0.0599	1.51	0.0581	1.51
96/40 M.T.	C & 1st	0.0585	1.63		
	2nd	0.0607	1.56		
	3rd	0.0603	1.67		
38/40 M.T. +	C, 1st & 2nd	0.0619	1.49	0.0595	1.55
28/40/M.T. +	3rd	0.0638	1.62	0.0633	1.58
54/20 M.T. +	4th	0.0638	1.44	0.0608	1.49
50/40 M.T.	5th	0.0610	1.60	0.0643	1.57
60/40 M.T.	Centre	0.0627	1.60		
	1st	0.0614	1.63		
	2nd	0.0616	1.68		

Table II.

MUTUAL AND DIRECT CAPACITIES OF A M.T. CORE, WHEN EACH OF THE REMAINING CORES OF THE CABLE ARE EITHER (i) INSULATED OR (ii) EARTHED.

Cable Make-up.	Layer.	Side cct. capacity (S) microfarad per mile.	Condition of each of the other cable cores.	Magnitude of Ratios:—			
				w/S.	m/S.	a/S.	P/S.
60/40 M.T. (2.6 mls. length)	Centre	0.059	Insulated	0.24	0.48	0.56	1.52
			Earthed	0.16	0.40	0.88	1.52
	1st	0.067	Insulated	0.20	0.50	0.58	1.39
			Earthed	0.16	0.45	0.76	1.39
	2nd (Outer)	0.064	Insulated	0.18	0.42	0.79	1.51
			Earthed	0.15	0.40	0.90	1.51
60/40 M.T. (176 yds. length)	Centre	0.0600	Insulated	0.266	0.447	0.572	1.64
			Earthed	0.180	0.362	0.915	1.64
	1st	0.0601	Insulated	0.240	0.426	0.670	1.63
			Earthed	0.183	0.368	0.897	1.63
	2nd (Outer)	0.0593	Insulated	0.199	0.339	0.900	1.70
			Earthed	0.175	0.324	0.990	1.70
24/100 M.T. (1.125 mls. length)	Centre	0.0620	Insulated	0.188	0.365	0.890	1.645
			Earthed	0.167	0.344	0.973	1.645
	1st (Outer)	0.0619	Insulated	0.185	0.368	0.906	1.645
			Earthed	0.167	0.350	0.978	1.645
14/100 M.T. + 36/40 M.T. (1.125 mls. length)	1st	0.0619	Insulated	0.245	0.476	0.545	1.531
			Earthed	0.203	0.436	0.716	1.531
	2nd (Outer)	0.0607	Insulated	0.227	0.434	0.682	1.587
			Earthed	0.215	0.421	0.733	1.587
28/100 M.T. + 48/40 M.T. (1.125 mls. length)	Centre	0.0625	Insulated	0.223	0.425	0.703	1.598
			Earthed	0.174	0.376	0.901	1.598
	2nd (Outer)	0.0605	Insulated	0.165	0.347	0.975	1.637
			Earthed	0.154	0.335	1.024	1.637

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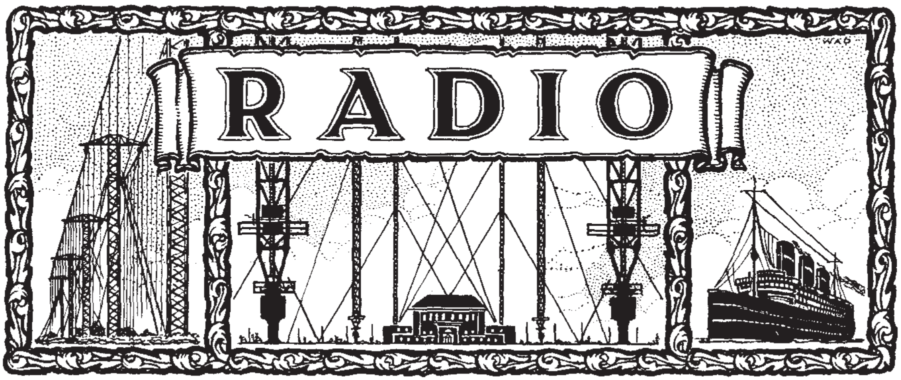


TRANS-ATLANTIC TELEPHONY.

A MESSAGE FROM SIR EVELYN MURRAY.

The opening of the transatlantic telephone service is an historical event in the sphere of communications, and I should like to take this opportunity to congratulate the Wireless Engineers of the Post Office who, in collaboration with our friends of the American Telephone and Telegraph Company, have achieved this notable success.

Credit is also due to the London Telephone Service and to the Traffic Staff for the smooth and efficient organisation at the Trunk Exchange, and last, but not least, to the admirable team of operators, who worked the service under the difficult and somewhat discouraging conditions of the opening day with enthusiasm and efficiency.

G. E. P. Murray.

A SHORT HISTORY OF THE DEVELOPMENT OF THE SERVICE.

Lt.-Colonel A. G. Lee, M.C., M.I.E.E., M.I.R.E.

Telephony by radio is no new thing, for it followed soon after the invention of radio telegraphy over a quarter of a century ago. Its development, however, languished until the advent of the thermionic valve which rendered it possible to control and amplify the speech currents in the various portions of the path between one talker and the other. The production of the radio waves in a form suitable for telephony may also be said to be dependent upon the valve, because while there are other methods of producing and modulating radio waves, the valve is by far the most convenient for radio telephony.

About 1914 the valve was becoming a practical article and in 1915 the American Telephone and Telegraph Company decided to attempt telephony by radio across the Atlantic. For this purpose they grouped in parallel a large number of small valves at the Arlington, U.S.A., radio station, and after some experiment succeeded in producing speech which was heard at the Eiffel Tower in Paris. After this came the invention by Carson of the single side-band, suppressed carrier, system of working and the development of the high power metal-glass water-cooled valve. Such was the state of affairs in 1923 when the Company again attempted telephony across the Atlantic, this time with such marked success that the Postmaster-General decided to co-operate with the American Telephone and Telegraph Coy. and the International Western Electric Coy. (now the International Standard Electric Comporation) in an attempt to still further develop the system for commercial working.

At this stage it became necessary to review the progress and possibilities and to outline the work necessary to ensure successful commercial operation. The inventions of the valve and the single side-band method formed the groundwork on which it was proposed to build. But for any engineering project it is necessary to know what specification has to be met. General experience of radio work had shown that fading of signals and disturbance by atmospherics were amongst the real difficulties encountered in long distance communications. Organizations were therefore set up on both sides of the Atlantic to measure these quantities, observations being taken at each hour of the day once each week. These measurements have been continued for nearly four years and have involved thousands of tests, and with the preliminary data of this sort on hand it became possible to decide what amount of power was necessary at the transmitter, what kind of receiving arrangements were desirable, and what was the best wave-length on which to work. From this point engineering design proceeded to the manufacture of a 200 k.W. telephony transmitter at Rugby, which was installed by the Western Electric Coy., using an aerial supported on the 820 ft. masts of that station, and also the installation of special receiving apparatus and the erection of a directional antenna at Wroughton, near Swindon. On the completion of this work two-way telephony across the Atlantic became possible and the first conversations took place on February 7th, 1926, between the Engineers engaged in the work on both sides. These first conversations were made using separate wave-lengths for each transmitter, but owing to the congestion in the ether and the practical impossibility of finding room for two separate wave-bands, it was decided to attempt to work both transmitters on the same frequency. Voice operated switching devices were designed for this purpose in which special means were taken to prevent atmospherics capturing the control of the switching devices, which is a trouble not present on ordinary land line telephony. After these arrangements had been successfully developed, it became necessary to clear a frequency band for commercial use. We had been working experimentally on Sundays to avoid interference with numerous radio telegraph services and it is a pleasure to record the very friendly spirit of co-operation in which the Government Administrations of Germany, Italy and Russia, as well as the Air Ministry and the Marconi Coy. in this country, arranged for the removal of their services to other wave-lengths in order to make room for the newcomer, Trans-Atlantic Telephony. In America the U.S. Naval Administration also assisted by clearing their stations from the wave-band required.

The engineering work of investigation, erection, development and testing having been satisfactorily concluded, the Traffic Staff took up the task of training the special staff of operators and developing the operating procedure, and practical trials of the system between officials of the Post Office on this side and those of the American Telephone and Telegraph Company on the other side of the Atlantic were instituted.

Finally, on January 7th, 1927, the day for opening the service to the public arrived. At the New York end Mr. W. Gifford, President of the American Telephone and Telegraph Coy., in the presence of a group of the officials of the Company and a number of press representatives, lifted his receiver at 8.45 a.m., New York time, and asked for Sir Evelyn Murray in London. He was immediately connected and in his greeting to Sir Evelyn Murray Mr. Gifford said:—

" To-day, as a result of very many years of research and experimentation, we open a telephonic channel of speech between New York and London. Thus, the people of these two great cities will be brought within speaking distance. Over 3,000 miles of ocean individuals in the two cities may by telephone exchange views and transact business instantly as though they were face to face. I know that it is your aim, as it is ours, to extend this service so that in the near future anyone in either of our countries may talk to anyone in the other. No one can foresee the ultimate significance of this last achievement of science and organization. It will certainly facilitate business; it will be a social convenience and comfort; and, through the closer bond which it establishes, it will promote better understanding and strengthen the ties of friendship. Through the spoken word, aided by the personality of the voice, the people of New York and the people of London will become neighbours in a real sense, although separated by thousands of miles.

" We are glad to have co-operated with you in this notable enterprise, and shall actively continue to work with you in extending and improving the service. I congratulate you upon your successful solution of your problems, and wish to extend to you and to your associates the greetings and good wishes of the officers and staff of the American Telephone and Telegraph Company and of their associates in the Bell Telephone System."

In reply Sir Evelyn Murray said :—

" The opening of a public telephone service across the Atlantic between London and New York is a conspicuous milestone on the road of telephone progress, and marks the beginning of a new epoch in the development of communication between our two countries. Personal conversation between Great Britain and the United States has emerged from the stage of experiment into a practical reality, and we are confident that the service which we are inaugurating to-day will be a boon to both nations, whether as an aid to commerce or as a medium of social and domestic intercourse, and will tend to strengthen the bonds which unite the two communities.

The Fifteen-Pound Touch.

John Bull—" That you, Sam? A happy New Year to you."
Uncle Sam—" You said a pocketful, John ! The same to you."

Reproduced from " Punch," 5-1-27, with permission of the proprietors. We might say that all the comments about the charges have been of the same good-natured description, although coupled with many hopes that they will come down soon.

" I am charged by the Postmaster-General to take this occasion to acknowledge the notable contributions which your company has been able to make, through its great engineering and research organization, towards the solution of the many baffling problems which have been encountered. We recognize, as we believe you recognize, that there are difficulties still to be overcome before the Translantic service can attain the standard of regularity and reliability at which we aim ; but we are convinced that there is no better means of solving these difficulties than by putting the service to the crucial test of daily use, and we share your hope that before long Transatlantic conversation will be available not only to the citizens of London and New York, but to every telephone subscriber in both countries.

" We of the British Post Office look back with pleasure upon the cordial co-operation with the

American Telephone and Telegraph Company, which has led to the success so far achieved, and on behalf of the Postmaster-General and the officers of the General Post Office I warmly reciprocate your greetings and good wishes. I now declare the service open to the public."

In Sir Evelyn Murray's room at the G.P.O. were gathered some of the officials of the Post Office who had been associated with the development of the service, Messrs. R. A. Dalzell, C.B., C.B.E., W. T. Leech, L. Simon and F. W. Phillips of the Secretary's Office, Col. T. F. Purves, E. H. Shaughnessy, and Lt.-Col. A. G. Lee, of the Engineering Department, and Lt.-Col. H. E. Shreeve of the American Telephone and Telegraph Company.

In this quiet way was launched one of the most outstanding events in Telephone history. There have been many marvellous inventions in telephony, including the most marvellous of all, the telephone itself, but even to our modern minds, rather surfeited with the wonders of scientific development, there is something which appeals to the imagination in being able to converse with another English speaking nation 3000 miles across the seas.

In looking back over the progress in radio telephony for the last 12 years, admiration must be expressed for the genius and far-sighted vision of the American Telephone and Telegraph Coy. and its associated Company, the Bell Telephone Laboratories, which at that time envisaged the spanning of the Atlantic telephonically and have since worked steadily and methodically at one development after another until the goal was reached. It is a striking example of the value of painstaking research, organised as it is in America on large lines, and illuminated from time to time by flashes of brilliance, which light the way from one stage of development to another.

THE LONDON-NEW YORK TELEPHONE CIRCUIT.

R. V. HANSFORD, D.Sc.

THE writer has been requested to give the readers of this Journal a general technical description of the Trans-Atlantic Telephony Circuit. The exigencies of space must necessarily limit the article to one of a general nature only, and I would refer those readers interested in specific details to one or other of the technical articles which have been published by the American Engineers who have been responsible for the development of the system. A short bibliography is given at the end of this article.

It seems necessary in the interests of clarity that any description of this complicated circuit should commence with a general schematic diagram of the London-New York circuit as given in Fig. 1, although this has been made so familiar by the popular press.

The circuit across the Atlantic is the equivalent of a long 4-wire telephone circuit. The channel from East to West is from London, by 85 miles of underground cable to Rugby, thence by radio to Houlton, Maine, and from there by 600 miles of open and underground lines to New York.

The channel from West to East is from New York, by 70 miles of underground to the Rocky Point Transmitting Station, thence by radio to the English Receiving Station at Wroughton, which is connected by 90 miles of underground to London.

The normal difficulties of a very long telephone circuit of this type, such as "echo" and "singing" effects, are accentuated by the variability of a circuit which includes two radio links. In an ordinary wire circuit, the conditions remain fixed and for a given speech-input volume at one end of the circuit, the level of speech-output at the other end is constant. Also, under modern conditions, the land line circuits are reasonably quiet and there is very little extraneous noise to disturb the telephone user. With radio links in the circuit, the conditions are very different. The signal strength received varies from hour to hour and sometimes from minute to minute; "atmospherics" are nearly always present and at times may be as loud as the signal which it is desired to receive.

A very real difficulty in modern radio communication is the congestion of the ether due to the ever-increasing number of stations. When it is borne in mind that a radio telephone service necessitates a very wide band of frequencies as compared with radio telegraph service, it will be realised that it is not an easy matter to find room for a telephone service between the wavelengths of 5000 and 6000 metres which will not interfere with existing telegraph services and will also be free from interference.

There are two possible means of reducing the frequency band utilised for such a service: the first is to reduce the band used for the transmission of speech to a minimum; the second is to use the *same* frequency band for the transmission in both directions.

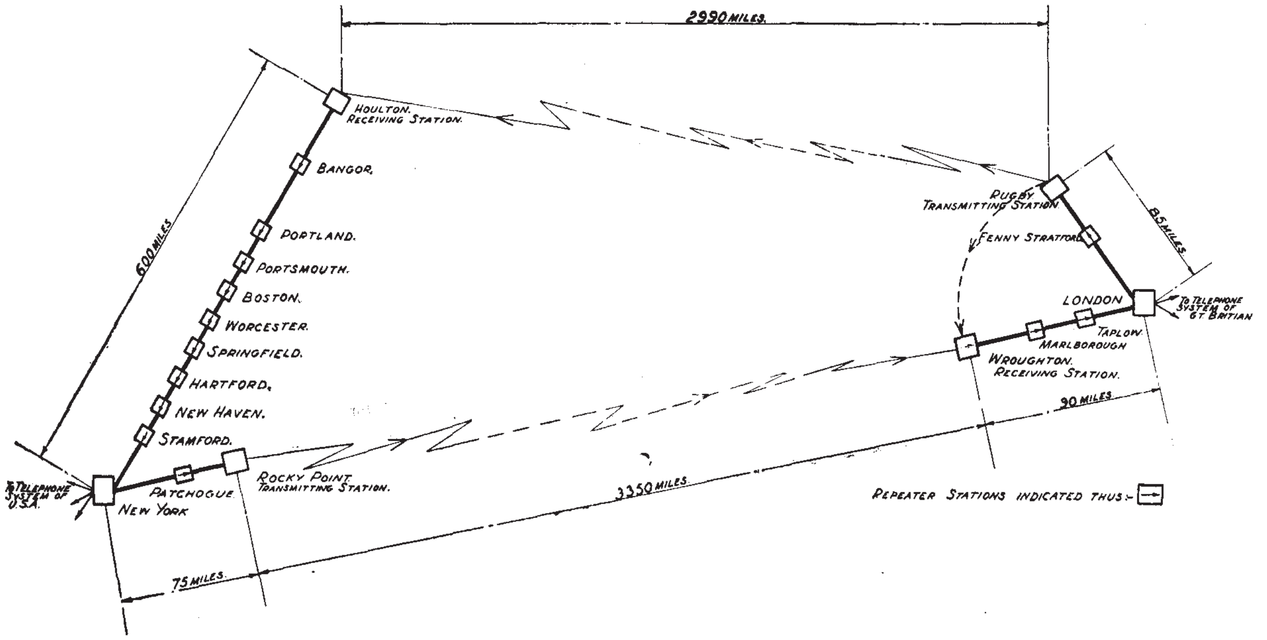

2990 MILES.
HOULTON. RECEIVING STATION.
BANGOR.
PORTLAND.
PORTSMOUTH.
BOSTON.
WORCESTER.
SPRINGFIELD.
HARTFORD.
NEW HAVEN.
STAMFORD.
600 MILES
TO TELEPHONE SYSTEM OF U.S.A.
NEW YORK
PATCHOGUE
ROCKY POINT TRANSMITTING STATION.
75 MILES.
3350 MILES.
RUGBY TRANSMITTING STATION.
FENNY STRATFORD
85 MILES.
LONDON
TO TELEPHONE SYSTEM OF GT. BRITIAN
TAPLOW.
MARLBOROUGH
WROUGHTON. RECEIVING STATION.
90 MILES.
REPEATER STATIONS INDICATED THUS:-

FIG. 1.—SKELETON DIAGRAM OF LONDON-NEW YORK TELEPHONE CIRCUIT.

As regards the reduction of the frequency used for a single transmission to a minimum, ordinary speech includes frequencies varying from about 50 to 8,000 cycles per second. It is not necessary, however, to transmit the complete range of the speech frequencies in order that intelligible speech may be received; speech of reasonably good quality can be transmitted notwithstanding that frequencies below 300 and above 3,000 cycles per sec. have been cut off. The usual type of radio-transmitting station using a modulated carrier would need a frequency range of 6,000 cycles to transmit even this restricted band, but by using the single side band suppressed carrier system (further discussed later) the radiation from the transmitting station can be limited to a single band of the order of 2,700 cycles.

The utilisation of this single side band system thus limits the frequency band by more than a half, but the use of different frequency bands for the transmission in the two directions, even when of such relatively narrow width, would occupy the greater part of the frequency spectrum corresponding to the band of wavelengths between 5,000 and 6,000 metres. It was felt therefore that a great effort should be made to utilise the same wave-length for the transmission in both directions, and this development has been realised. The magnitude of the difficulty will be understood when it is stated that the strength of the signal at the receiving station at Wroughton (near Swindon), due to the transmitting station at Rugby, is from one thousand to ten thousand times as strong as the signal received from America on the *same* wavelength, and that the system as a whole has to discriminate between these signals.

The Post Office Radio Station at Rugby was designed as a thermionic valve station and the power plant, etc., was therefore very suitable for the addition of a radio-telephony transmitter. The h.t.d.c. generators and alternators provided for the main anode supply and the filament heating respectively of the telegraphy transmitter are also used for the telephony installation. The article by Mr. Shaughnessy in the last number of this Journal included a general description of the plant common to the telegraph and telephone installations, such as power plant, etc., together with an account of the type of inductances used.

The telephony transmitter itself was provided by the Standard Telephones and Cables Co., Ltd., with the consulting advice of the Bell Telephone Laboratories, Inc., which had been responsible for the telephony installation at Rocky Point in America.

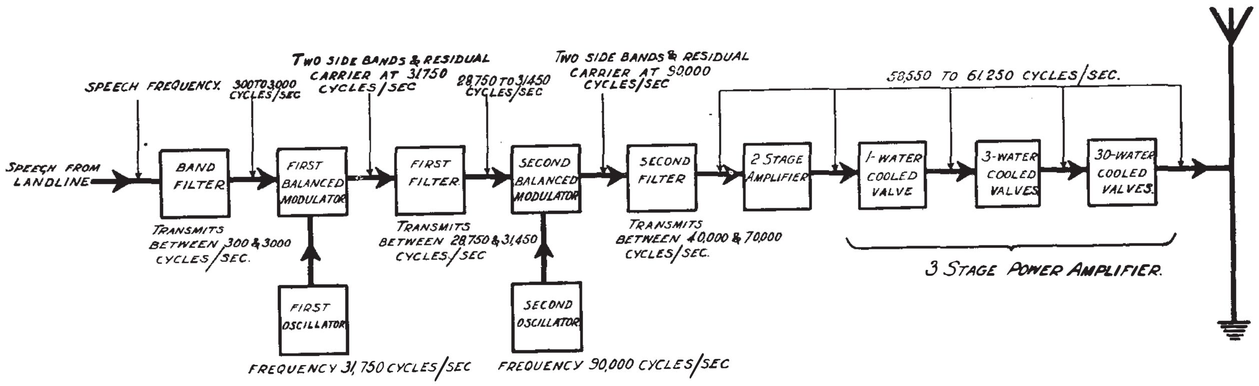

SPEECH FROM LANDLINE
SPEECH FREQUENCY.
300 TO 3000 CYCLES/SEC
TWO SIDE BANDS & RESIDUAL CARRIER AT 31,750 CYCLES/SEC
28,750 TO 31,450 CYCLES/SEC
TWO SIDE BANDS & RESIDUAL CARRIER AT 90,000 CYCLES/SEC
58,550 TO 61,250 CYCLES/SEC.
BAND FILTER
FIRST BALANCED MODULATOR
FIRST FILTER
SECOND BALANCED MODULATOR
SECOND FILTER
2 STAGE AMPLIFIER
1-WATER COOLED VALVE
3-WATER COOLED VALVES
30-WATER COOLED VALVES
TRANSMITS BETWEEN 300 & 3000 CYCLES/SEC.
TRANSMITS BETWEEN 28,750 & 31,450 CYCLES/SEC
TRANSMITS BETWEEN 40,000 & 70,000 CYCLES/SEC.
3 STAGE POWER AMPLIFIER.
FIRST OSCILLATOR
SECOND OSCILLATOR
FREQUENCY 31,750 CYCLES/SEC
FREQUENCY 90,000 CYCLES/SEC

Fig. **2**.—Schematic Diagram showing arrangement of Radio Telephony Transmitter at Rugby.

A brief description will now be given of the radio transmitter at Rugby, beginning with the production of the single side band. A diagram showing the general arrangement of the complete radio transmitter is given in Fig. **2**.

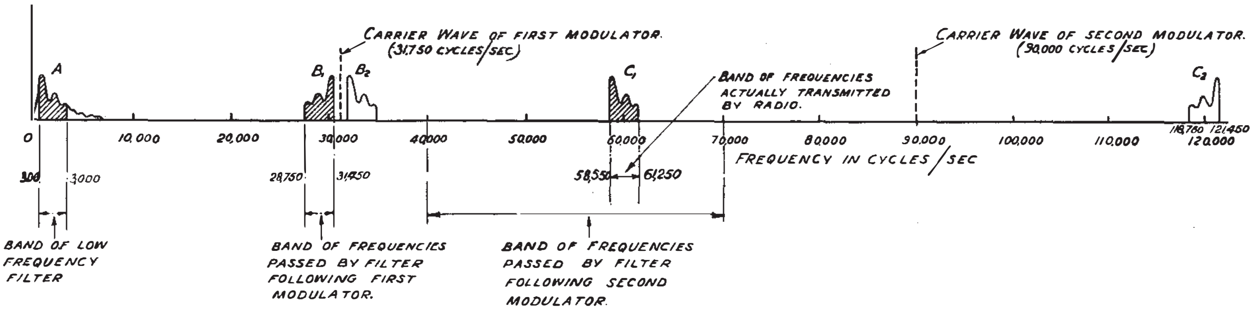


Fig. **3**.—Frequency Spectrum showing relationship of Frequency Bands in a Transmitter producing a Single by Double Modulation.

The speech frequencies arrive at the radio transmitting station, it should be noted, as a *single* band of frequencies represented as A in the frequency spectrum of Fig. **3**. By means of filters the frequencies below 300 and above 3,000 cycles per sec. are cut off and the speech frequencies used for the transmission are reduced to those within this 2,700 cycle band.

It is well known that if a high frequency F_1 (called the carrier) is modulated in amplitude at a low frequency f_2, there are produced, in addition to the carrier frequency, two resulting frequencies of $F_1 + f_2$ and $F_1 - f_2$ (corresponding to the upper and lower side bands respectively). Therefore if the frequency band A is used to modulate the carrier (F_1) of 31,750 cycles/sec. the result is the production of two side bands B_1 and B_2. This modulation is carried out by means of a balanced modulator which produces the two side bands with a minimum of carrier frequency. A skeleton diagram of the balanced modulator is given in Fig. **4**. The device uses two valves and it will be observed that the carrier is applied to both grids in parallel while the speech input causes one grid to be positive when the other is negative. The result is that the two side bands are produced in the output from the device and the carrier is largely balanced out. A band filter now selects the side band B_1, thus eliminating the remainder of the carrier and the side band B_2.

This band of frequency, B_1, is now used to modulate a carrier (F_2) at the frequency of 90,000 cycles per sec., giving the two side bands C_1 and C_2 which are separated by 60,000 cycles. (See Fig. 2). A wide band filter now selects the side band C_1, which is in the final frequency form required, and this is amplified through successive stages from 3 milli-watts to the final aerial power of the order of 100 kilo-watts. It will be observed that the difference between the two carrier frequencies ($F_2 - F_1$) of 58,250 cycles per sec. is the value of the single frequency which would have to be modulated by the original speech to produce the final result, and that this carrier frequency of 58,250 cycles which has to be re-inserted at the receiving station is not actually generated, as such, at any stage of the generation of the high frequency power at the transmitting station.

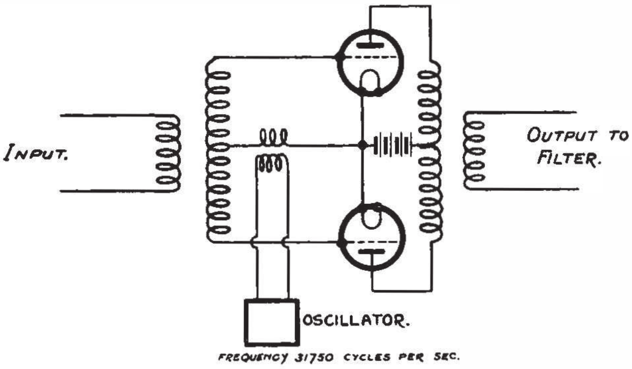


FIG. 4.—SKELETON DIAGRAM OF BALANCED MODULATOR.

The advantages of the double modulation, *i.e.*, the successive use of two carrier frequencies, are briefly as follows:—

1. It is easier and more economical to build an efficient filter to select the single side band at the lower frequency (and this filter can be a fixed filter); this single side band can then be moved by the second modulator to the required transmission frequency.
2. It permits an easy adjustment of the transmitted wave-lengths with fixed filters; the second fixed filter transmits a wide band of frequencies from about 40,000 cycles to 70,000 cycles and therefore a variation of about 30,000 cycles in the radio transmission can be obtained by altering the frequency of the second carrier, which is a comparatively simple manner.

The advantages of the single side band suppressed carrier system can be summarised briefly as:—

1. Economy in power; in the usual method of radio telephony transmission $\frac{5}{6}$ of the total energy radiated is con-

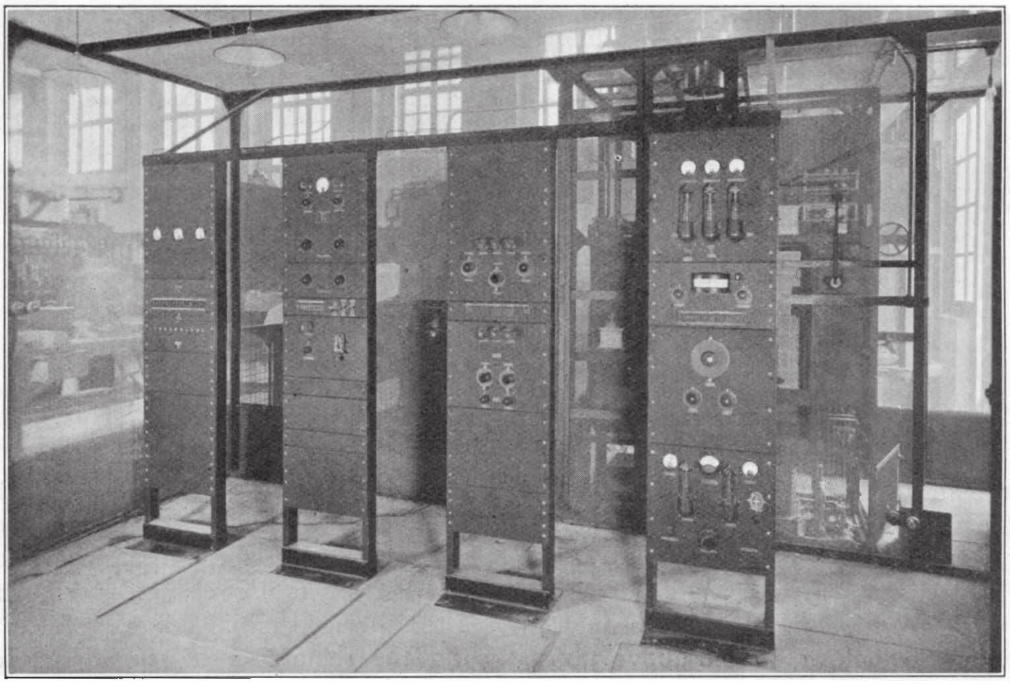


FIG. 5.—VIEW OF SIDE BAND EQUIPMENT OF RADIO TELEPHONY TRANSMITTER AT RUGBY.

tained in the carrier. There is a further saving in power by the suppression of one side band in addition to the carrier.

2. The frequency range is reduced by one half with a consequent economy in the frequency spectrum for other radio transmissions.
3. The design of the power amplifiers and the circuits associated with the antenna system is greatly simplified since the frequency band over which uniform amplification is aimed at as an ideal, is halved.
4. The narrow frequency band permits the use of a more selective receiver and consequently improves the signal-noise ratio at the receiving station.
5. The fluctuations in signal strength at the output of the radio receiver are less; the signal strength at this point depends on the product of carrier amplitude and the side band amplitude and by the insertion of a *constant* carrier amplitude at the receiving station one variable is eliminated.

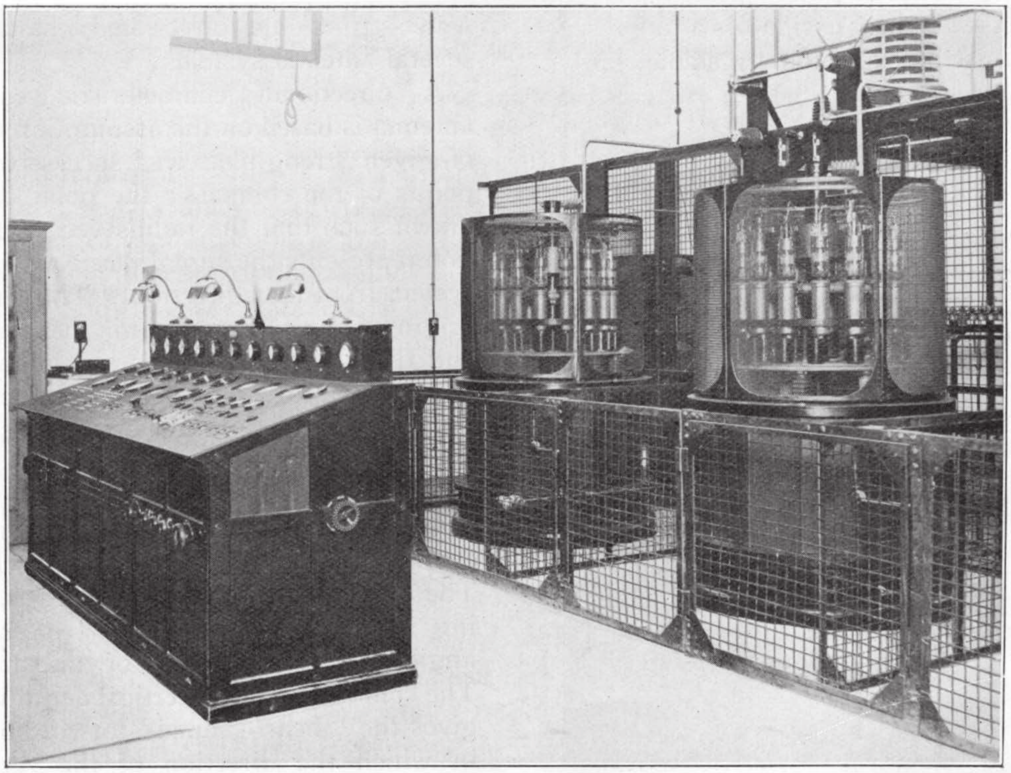


FIG. **6**.—VIEW OF POWER AMPLIFIER AND CONTROL TABLE OF RADIO TELEPHONY TRANSMITTER AT RUGBY.

The side band equipment at Rugby is illustrated in Fig. **5**. Beginning from the left the first rack contains power controls, fuse panels, alarms, etc.; the second rack contains the speech input equipment, included in which are facilities for measuring and adjusting the level of the speech received from London; on the third rack is mounted the first and second modulating circuits and the output from this rack is in the final frequency form; the last rack contains the first two stages of high frequency amplification and also a variable frequency test oscillator.

The amplification of the output from the side band equipment to the full aerial power is carried out by means of a three-stage high-frequency power amplifier. The valves used in the three stages are all of the 10 kilo-watt water-cooled type, manufactured by the Standard Telephones and Cables Co., Ltd., at their New Southgate Works. The first stage uses one valve, the second stage utilises three valves and the last stage consists of 30 such valves in parallel, *i.e.*, 2 banks of 15 each. The valves in all these stages use the same power supply from the main h.t.d.c. generators.

In Fig. **6** the two units of 15 valves which form the last stage of the power amplifier can be seen; in front of them is the control table from which central position the duty officer is able to watch and control the complete installation.

The question of radio reception will now be considered. It is necessary to replace the carrier at the receiving station and this may be done in one or two stages, that is, it may be added as a single carrier frequency of 58,250 cycles or double demodulation may be used with two oscillators similar to the method of double modulation utilised at the transmitting station. The accurate re-insertion of the carrier is essential if the received speech is to be of good quality and therefore the oscillator or oscillators at the receiving station must be exceptionally stable.

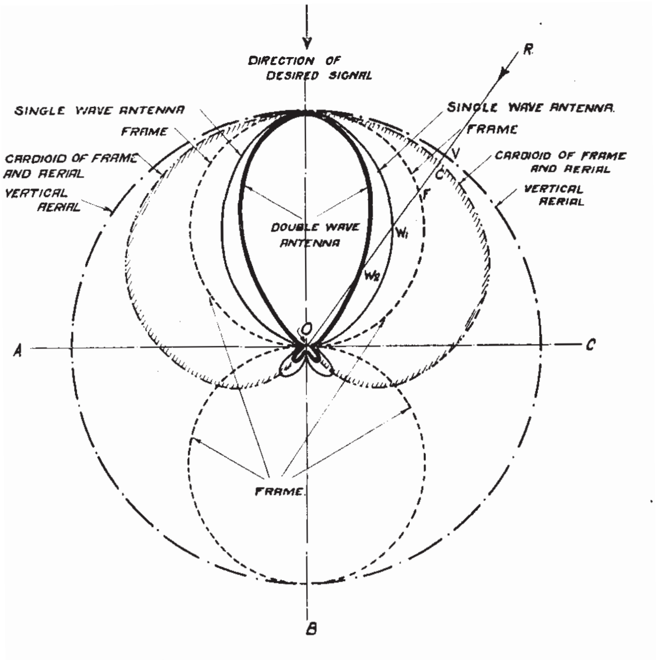


Fig. 7.—Directional Characteristics of Various Receiving Antenna Assuming Equal Reception from Direction of Arrow.

The problem of long-distance radio reception is not one of amplification, which under modern conditions is a matter of well-known thermionic valve technique. It is the problem of obtaining what is called a good signal/noise ratio. It is of little consequence how low the required signal is in level if the noise is relatively much lower. Experience shows that the level of the signal to be received should be of the order of 30 T.U. stronger than the noise in order to provide a commercial service. This problem of signal noise ratio is essentially one of selectivity. The first step is to obtain frequency selectivity in the receiver itself, which means that it should have a very sharp cut-off on each side of the 2,700 frequency band it is desired to receive. In the interests of good quality the frequency characteristic within this band should be practically constant.

Atmospherics may come from any and every direction; therefore, having obtained frequency selectivity by means of the receiver, the second step is to discriminate between the desired signal and interference of all kinds by having an antenna system with directive selectivity. This can best be explained by reference to Fig. **7**, which gives the directional characteristics of several antenna systems.

A directional characteristic curve of an antenna is based on the assumption that a signal of given strength arrives successively from all points of the compass; the polar curve is then drawn such that the radius vector in any direction represents the signal *received* by the antenna system from that direction. Thus in Fig. **7** the origin of the vectors for *all* the curves is at O and the magnitude of the signal received from any selected direction OR is represented by OV, OC, OF, OW_1 *or* OW_2, depending on the type of antenna system used.

It is clear that a vertical antenna will pick up equally well from all directions and that its characteristic curve is therefore a circle as shown. The curve for a frame is two circles, thus showing the well-known " null " points at right angles to the direction of maximum signal. The combination of a vertical aerial with a frame gives the " heart-shaped " or cardioid diagram, in which the direction of the zero signal is exactly opposite to the direction of the maximum signal.

A directional antenna of an entirely different type is that known as the Wave Antenna. Such an antenna consists of two wires erected on ordinary telephone poles extending in a straight line in the direction from which it is desired to receive. Its length is of the order of a wavelength, which means that it is over 3 miles in the present case.

With such an antenna the signal depends on the " tilt " of the wave-front (*i.e.*, the deviation from the vertical) and the E.M.F.'s consequently induced by the electro-magnetic wave as it

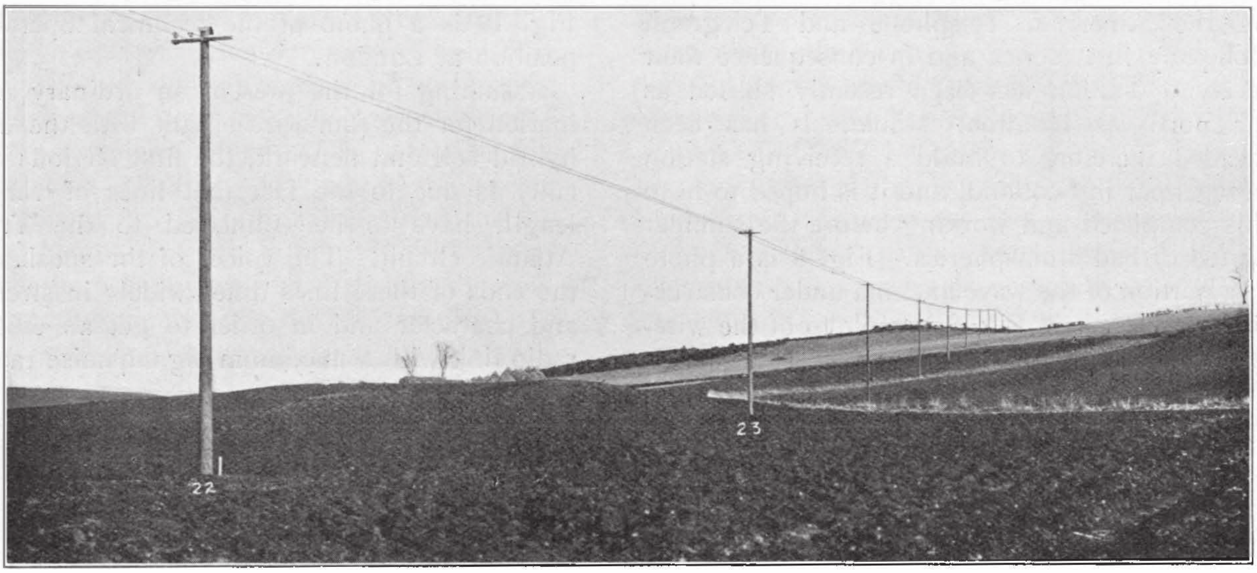


FIG. 8.—A PORTION OF THE WAVE ANTENNA FOR THE RADIO RECEIVING STATION AT CUPAR.

passes along the antenna; this is in contradistinction to the ordinary antenna or frame where the signal strength is a function of the vertical dimensions. The directional diagram of such an antenna is shown in Fig. 7 and is clearly to be preferred to any previously mentioned, the reduction in the reception of signals or or atmospherics from directions behind the direction of the desired signal, *i.e.*, within the 180° A.B.C., being specially noticeable. A double wave antenna can be obtained by erecting two parallel single wave antennæ about 2 miles apart and combining them by transmission lines to the receiving station.

A directional diagram for a double wave antenna is given in Fig. 7 and the improvement as regards the "tails" at the "back end" is very marked. The Post Office uses such a double wave antenna at Wroughton (near Swindon), which is the present receiving station.

Unfortunately the data obtained over a considerable period indicate that difficulty would be experienced, on account of the summer atmospherics, in maintaining a commercial service from Wroughton during the overlapping business day all the year round. Experiments were therefore made to ascertain if better receiving conditions were available elsewhere in Great Britain. Experiments showed that in Scotland atmospherics are generally less than at Wroughton and also that as the latitude of a receiving station became higher the signal strength became relatively greater than calculations would lead one to expect. This is in accord with the experience previously obtained

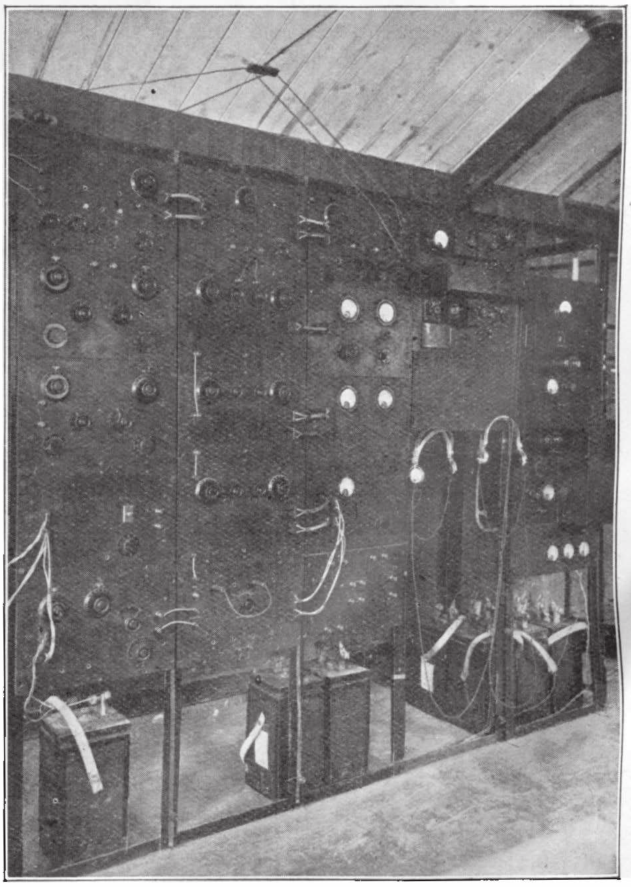
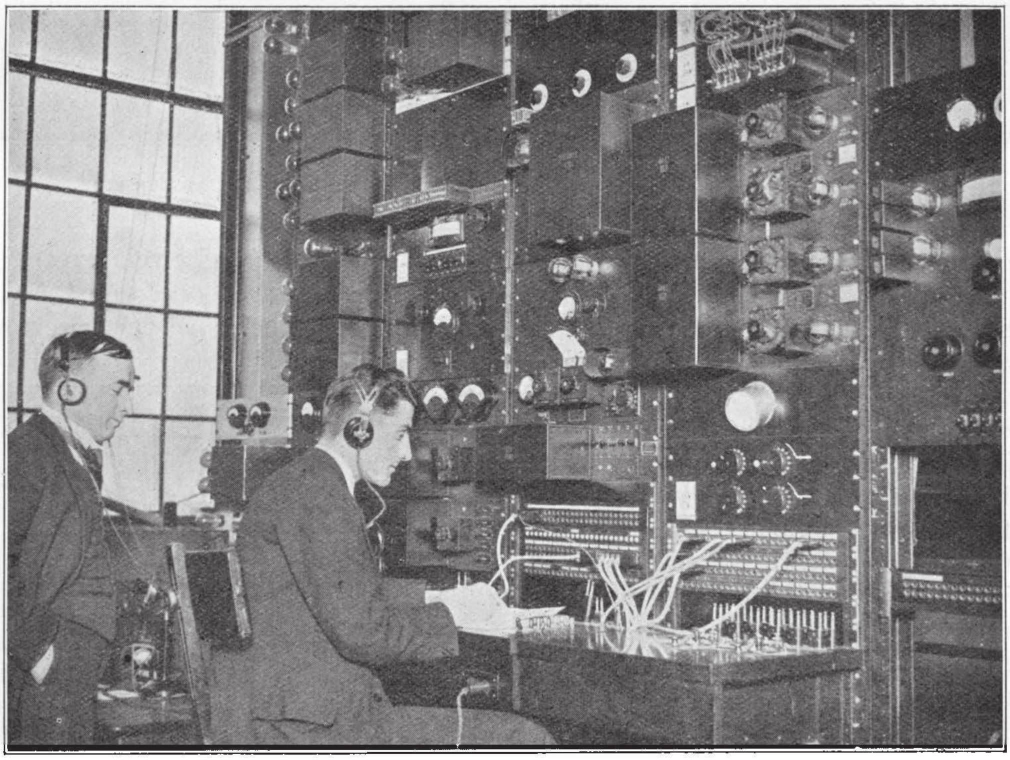


FIG. 9.—WIRELESS RECEIVER AT WROUGHTON.

by the American Telephone and Telegraph Company in America and in consequence their receiving station has been recently shifted as far north as Houlton, Maine. It has been decided therefore to build a receiving station near Cupar in Scotland, and it is hoped to have this completed and working before the summer period of bad atmospherics. Fig. **8** is a photo of a portion of the wave antenna under construction at Cupar and Fig. **9** is a photo of the wireless receiver at Wroughton.

Fig. **10** is a photo of the technical operator's position at London.

Assuming for the present an ordinary termination for the four-wire circuit with the usual hybrid coil and network, the first obvious difficulty is due to the fact that lines of varying length have to be connected to the Trans-Atlantic circuit. The voices of the speakers at the ends of these lines differ widely in strength and character and in order to get an efficient radio link with a maximum signal/noise ratio it is essential that every person using the circuit should fully load the radio transmitter in order to produce the maximum signal. Therefore at London (and New York) the duties of the technical operator include the adjustment of the amplification so that the speech sent to the transmitting station is reasonably constant.



[*Photo by Pacific and Atlantic Photos Ltd.*]

FIG. **10**.—TECHNICAL OPERATOR'S POSITION AT THE LONDON TERMINAL OF THE LONDON-NEW YORK CIRCUIT.

Referring back to Fig. **1** there will be, as explained previously, a large " throw-in " from the transmitting station to the receiving station on the same side of the Atlantic. There will consequently be a large gain round the circuit London-Rugby-Wroughton-London which will

We now come to the problem of combining the two sides of the four-wire circuit at the terminal stations, *e.g.*, the combination of the outgoing circuit to Rugby with the incoming circuit at Wroughton into a two-wire channel which can be connected to the ordinary telephone system of the country. The special requirements of this radio circuit necessitate the provision of special technical control points at London and New York equipped with control and testing apparatus and at which there are skilled technical operators in continual observation while the circuit is in commercial service.

therefore "sing" and render conversation impossible unless special measures are taken. This difficulty is overcome by the use of voice operated devices at London and New York, the general principle of which can be explained by consideration of Fig. **11**, which represents diagrammatically the terminal position on the British side.

It will be seen by reference to this diagram that normally the circuit to the transmitting path is open at D and the circuit from the receiving station is closed at E. Under these conditions the subscriber on this side can hear the speech from America, but the break at D stops the circuit "singing." When he speaks the voice currents pass through the repeater G to device B (high impedance) and operate the device C which closes D and opens E. This permits him to speak and the circuit restores automatically to enable him to receive a reply.

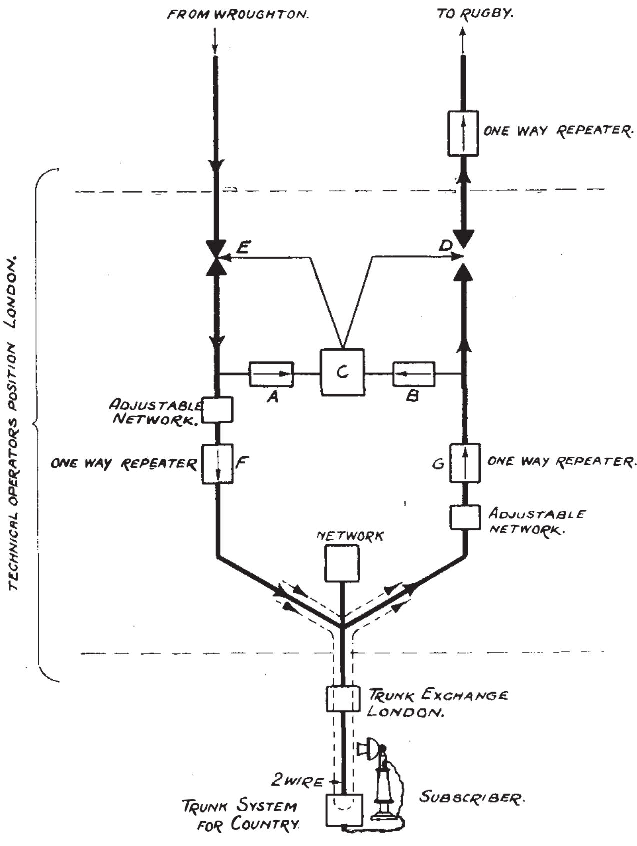


Fig. **11**.—Skeleton Diagram of Termination of 4-Wire Circuit between London and New York.

Since the ideal of a perfect balance with a four-wire circuit is not at present practicable, it is clear that if the received currents due to speech or atmospherics reach a certain level, "out of balance" or "echo" currents may get into the circuit G B C by one of the dotted paths and operate C, thus cutting off the received speech; to avoid this it is necessary that a portion of the received currents passing up the high impedance path A.C. shall prevent device C being operated by "echoes," etc., of the received speech. These are very stringent conditions and speaking in general terms they mean that the subscribers' voices have to clear their own path by the operation of a sensitive device. After the speech currents have passed the device has to restore quickly enough to enable the reply from America to be received. This operation has to be quick, certain and effective or the subscriber will be inconvenienced by the loss of intelligibility. Every time the subscriber says a single short word such as "Yes" the word itself has to cause a definite switching change of the circuit conditions and the special apparatus required has to be under the careful control of the technical operator in order to ensure that the varying types of voice fully operate the device.

Alternative devices for this unique requirement in the history of telephony have been developed by the American Telephone and Telegraph Company and by the Post Office Engineering Department of this country and both are available at London as alternatives. The device of the former organisation is an ingenious and extraordinarily reliable combination of mechanical relays, operated by the voice currents after amplification and detection, and associated with electrical delay circuits. The device of the P.O. Engineering Department is a thermionic valve device and is described elsewhere in this Journal. Each of the systems has been proved to be very satisfactory and reliable in operation. Fig. **12** is a photo of the voice-operated device of the American Telephone and Telegraph Company as installed at London.

These voice-operated devices by nature of their essential sensitivity will not function entirely satisfactorily if the long distance and other lines connected to the Trans-Atlantic circuit are not of a high grade as regards both noise and level of speech. A circuit which may be satisfactory for long distance land-line communication may have a noise level which makes it quite

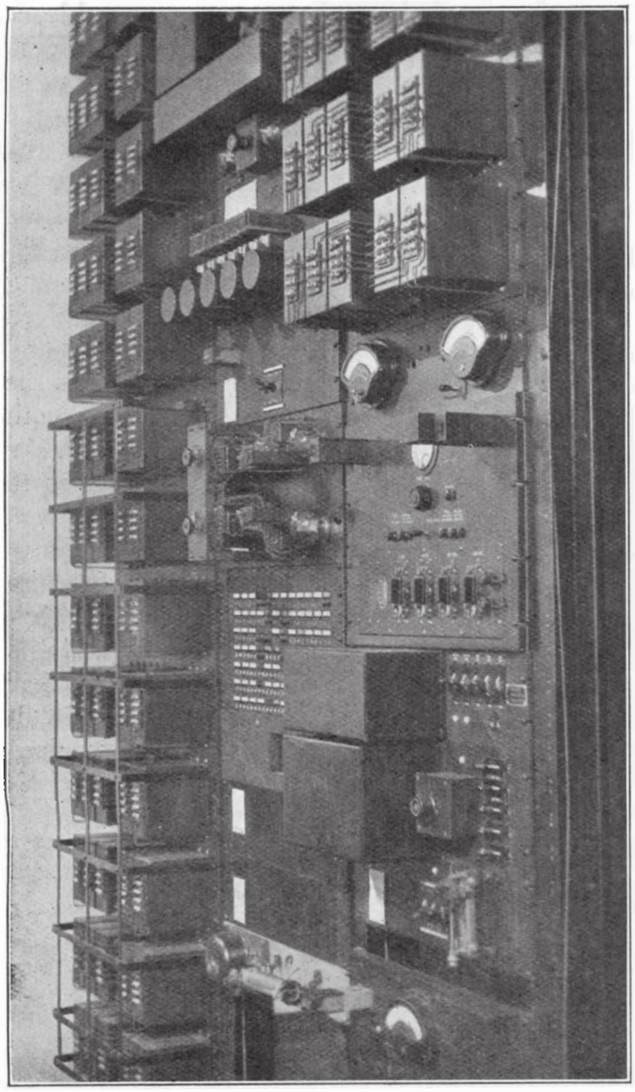


FIG. 12.—VOICE-OPERATED DEVICE DEVELOPED BY THE A.T. AND T. COY. FOR THE TRANSATLANTIC TELEPHONE CIRCUIT.

unsuitable for extension to the Trans-Atlantic radio circuit.

Finally, it is unnecessary to explain to the readers of this Journal that, with the system described, no claim is made for secrecy. It is, however, difficult to receive both sides of the conversation and it is thought that the average user will not be deterred by the fact that his conversation, or part of it, may be overheard by a stray radio eavesdropper. However, the Engineer-scientist is indefatigable and the problem of secrecy must soon yield to the same patient research which has conquered the great problems involved in the establishment of commercial Trans-Atlantic telephony.

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TRANS-ATLANTIC TELEPHONY.

THE POST OFFICE DIFFERENTIAL VOICE-OPERATED ANTI-SINGING EQUIPMENT.

C. A. Beer, Wh. Sch., A.C.G.I., and G. T. Evans.

INTRODUCTION.—The use of the same wavelength in both radio channels of the Trans-Atlantic Radio telephone circuit could not be realised until a practicable arrangement had been devised to prevent the radiated energy from the Rugby radio transmitter being returned through the radio receiver at Wroughton into the land wire system at such a high level that "singing" and "echo" effects would render telephonic conversation with America impracticable.

On account of the enormous magnitude of the electric field produced by Rugby at the Wroughton receiving station—65 miles distant—in relation to the more feeble field received from the American side, the consequent "gain," inherent in the path from *a* to *b*, in Fig. **1**, when B is adjusted to amplify the speech waves from America, necessitated a more effective means for the prevention of "singing," than that of the Hybrid Coil loss method shown schematically in the same figure and which is usually employed for repeatered circuits.

This article describes briefly a device which has been developed for the suppression of Singing and Echo effects in the circuit and this device is in satisfactory operation at the junction or terminal of the transmitting and receiving lines in London.

The device essentially consists of a system of Thermionic Valve Relays which are operated by voice currents in such a manner that the circuit is only operative in one particular direction at a time, although the principle of utilizing a hybrid coil and balancing network is taken advantage of in order to prevent, as far as possible, currents travelling in the path BD towards A from entering the opposite bound-path DC, Fig. **1**.

Referring to Fig. **2**, the path from the receiving station B to the subscriber's telephone at A is normally operative while a "loss" is introduced by the device into the path towards the radio transmitter to prevent the circuit singing.

When the subscriber at A speaks or utters a syllable the path AC, Fig. **3**, is made operative and a loss is made to occur in the receiving path BA. As a matter of fact the loss in the path BA is established before the loss in the path AC is removed, otherwise, the circuit would be in a singing condition during the transitory period.

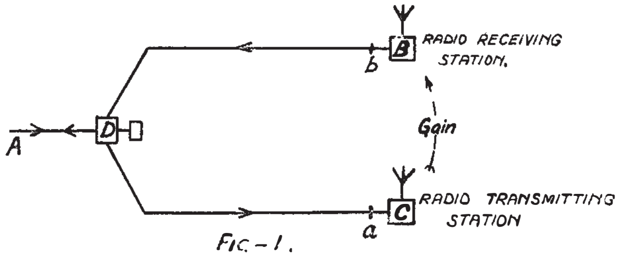


Fig-1.

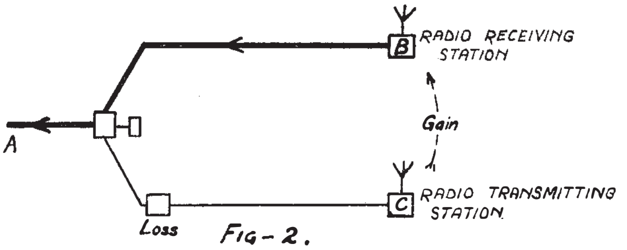


Fig-2.

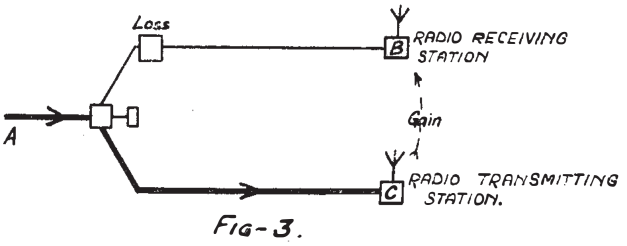
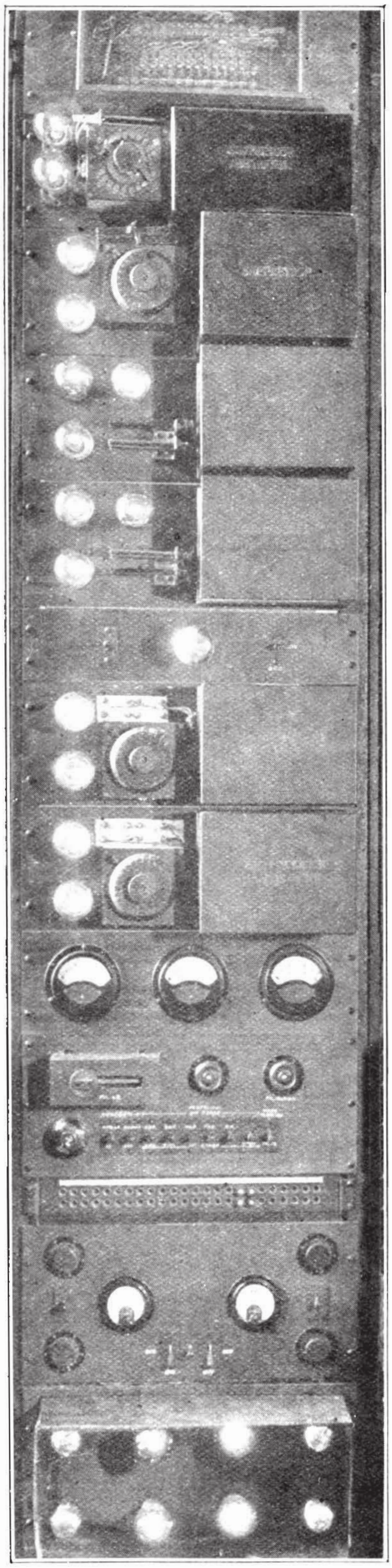


Fig-3.

Schematic of the 4-wire Arrangement.

When the subscriber at A ceases to speak or pauses during conversation the circuit will revert to the normal condition of Fig. **2**. In reverting, the loss is re-established in the transmitting line before the receiving line is again made operative.

Since the circuit is always in a one way condition "singing" cannot occur. Moreover, the complete device, as will be explained in subsequent paragraphs, is designed so that false operations by echoes is prevented.



THE P.O. DIFFERENTIAL VOICE-OPERATED ANTI-SINGING EQUIPMENT.

Outside the scope of this article a considerable amount of research work has been carried out in connection with (1) the sensitivity of the device to enable the weakest syllables of speech to be transmitted; (2) the discrimination that must be provided so that echoes, atmospherics and line noises do not cause false operations, and (3) the proper time intervals of operation necessary, so that the presence of a voice operated device shall not be manifest to the listener, and two-way conversation be satisfactorily effected. Mention, however, must be made of one feature of the experimental equipment which was necessary in connection with the development of the device. A circuit, shown schematically in Fig. **4**, was set up for the purpose of simulating as far as possible the British end conditions of the Trans-Atlantic circuit.

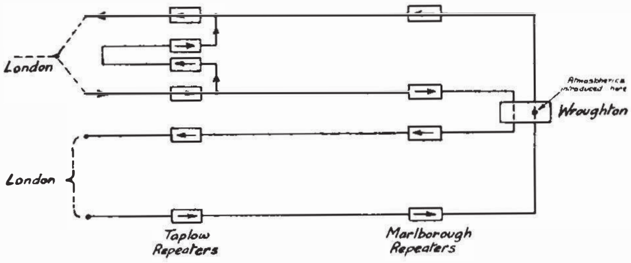


FIG. **4**.—EXPERIMENTAL SIMULATING CIRCUIT.

The arrangement consisted of two repeatered cable circuits from London to Wroughton and back. At Taplow, where the "go" and "return" circuits were repeatered, two separate repeaters joined in cascade and connected across the transmitting and receiving lines simulated the gain across the Rugby-Wroughton path. Atmospherics were introduced when necessary into the lines from the radio receiver at Wroughton. By this means a considerable amount of the data necessary for the design of the device was obtained.

Voice Operation—Sensitivity.—The ability to render operative the transmitting line, and thus enable every syllable to be transmitted, depends —provided the time of operation is kept to within a few thousandths of a second—on the sensitivity of the device in relation to the magnitude or intensity of the speech delivered to it. Voice currents delivered at the output of an ordinary subscriber's instrument have widely different magnitudes for different sounds spoken into it. For example, generally the sound "Ah" produces a substantial amount of power, while the output from the vowel "e" is very feeble. If the device be not sufficiently sensitive, initial parts of certain syllables will be "clipped." For instance, insufficient sensitivity would make the word "England" appear to the listener as "gland," while the same sensitivity would show no initial clipping on the word "landing"; and in the latter case a "hangover" feature in the operation of the device ensures the transmission of the end syllable.

It was found that speech from an ordinary subscriber's set delivering reference volume at, say, the point B in Fig. **5**, was satisfactorily transmitted without clipping, if the transmitting line were rendered operative by .0032 milliwatt of alternating current at 1300 cycles applied to the line at the same point in the system.

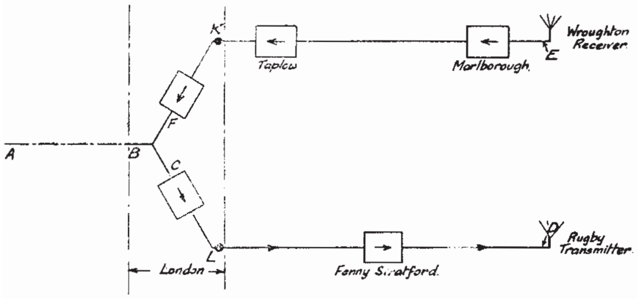


FIG. **5**.—SCHEMATIC DIAGRAM OF CIRCUIT IN THIS COUNTRY. Voice-operated equipment indicated by dots at K and L.

Singing.—Referring to Fig. **5**, the transmission equivalents of the various parts of the circuit located in this country are as follows:—

From C to D a transmission gain of 5 T.U. is normally existent and this is increased by the Technical Operator to a maximum of 30 T.U. gain when the subscriber at A produces speech at the two-wire junction B, which is 25 T.U. down in relation to reference volume. This means that the speech or other noise level at D is 30 T.U. higher than at C. From D to E *via* the Rugby and Wroughton path the nett gain may perhaps be approximately 50 T.U. For example, a typical record shows that at Wroughton the signal field strength received from Rugby and Rocky Point (America) were 18,900 and 3.7 micro volts per metre respectively. The effective gain is, however, less than that indicated by the field strengths on account of the discrimination afforded by wave antenna reception. From E to F a normal gain of 5 T.U. occurs, and provision is made whereby the equivalent may be varied from a gain of 10 T.U. to a loss of 20 T.U. A reduction in the gain, *i.e.*, lowering of the volume of speech delivered to the two-wire circuit, may become necessary when considerable noise is present in the radio link. From F to C is a loss, the magnitude of which varies considerably, and a variable transmission time factor is present due to reflections or echoes from the extension circuit BA.

The circuit C D E F C will sing if there is a nett gain. Therefore adding the gains in the links of the circuit as above designed, we have:

C to D	max.,	gain	30 T.U.
D to E		gain	50 T.U.
E to F		gain	10 T.U.
F to C	min.,	loss	6 T.U.
		Nett gain	84 T.U.

It is this gain of 84 T.U. that has to be offset by a loss introduced by the voice operated device at either K or L.

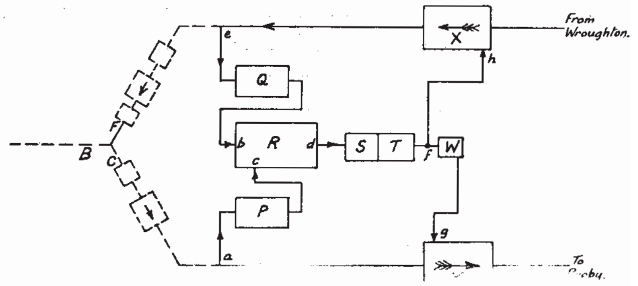


FIG. **6**.—DIAGRAMMATIC ARRANGEMENT OF ANTI-SINGING VOICE-OPERATED EQUIPMENT.

General Description and Operation of Device.—Fig. **6** shows diagrammatically the circuit arrangement at London, the voice operated equipment being drawn in full outline.

Considering firstly the main 4-wire circuit, when a conversation is not taking place, the singing is prevented by means of the repeater Y in the "Go" line. Under these conditions the grids of the first stage valves of this repeater are negatively primed sufficient to cause it to produce a transmission loss of the order of 100

T.U., instead of the zero gain, at which this repeater is used when it is operative. When this repeater is inoperative, the repeater X, in the "Return" line is operative, and *vice versa*.

Speech from a subscriber connected to London is received on the two-wire extension at B, whence it is transmitted to C and "*a*"; and at the latter point the speech is normally at the level of 10 T.U. above reference volume. At "*a*," the speech voltage is applied to the amplifier P, thence through R (from "*c*" to "*d*") and S, to the rectifier T, so that, while the London subscriber is actually speaking, there is generated at "*f*" a unidirectional voltage which, by means of a condenser-resistance combination, is maintained at about 40 volts.

During the rise of the voltage at "*f*" and as it reaches approximately 5 volts its application at "*h*" on the receiving suppressor repeater X, renders the latter inoperative, and at an infinitesimally short period of time afterwards a higher unidirectional voltage, applied to the valve W, causes the removal of the large grid bias at "*g*" and the transmitting suppressor repeater Y becomes operative for the period of transmission of speech.

After the cessation of speech from the London end the repeater Y at first becomes inoperative after which X becomes operative, this condition remaining until London speaks again.

Speech from New York, *via* Wroughton, arrives through X, "*e*," F and B and normally its level at the point "*e*" is 10 T.U. below reference volume. The voltage at "*e*" is applied, *via* the amplifier Q, to "*b*" in R where it is rectified and the unidirectional voltage, generated across a resistance and resistance-condenser combination in R, prevents a voltage arriving at "*c*" from being transmitted to "*d*." That is, during the passage of current in the receiving line, and for a certain length of time after its cessation, a bias of a small or large magnitude is impressed on R to retard, or completely suppress, the effect of any voltage at "*c*" which would otherwise cause a false operation of the device with the consequent liability of cutting off, or clipping, of the received speech, or the transmission of an "echo" *via* C *a* Y to New York.

Under conditions of heavy atmospherics on the receiving line the bias so produced *via* "*e*" and the amplifier Q may be of sufficient magnitude to prevent speech from the London subscriber satisfactorily operating the device. That is, in the presence of atmospherics, the amplification of Q has to be reduced, with the result that it is sometimes necessary to degrade the receiving repeater, shown dotted, in order to prevent the echo of the received speech, *via* F, C, "*a*," from causing a false operation. Under these circumstances a lower received speech volume is consequently delivered to the London subscriber.

Under the following headings a more detailed description is given of the separate apparatus and its performance.

Suppressing Repeaters.—These are indicated as X and Y in Fig. **6**, and their common circuit diagram is shown in Fig. **7**.

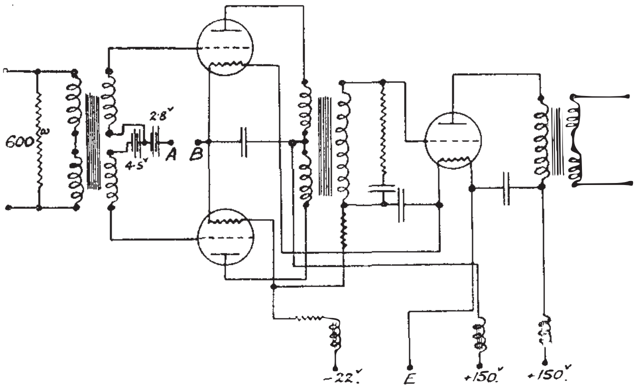


FIG. **7**.—CONNECTIONS OF SUPPRESSOR REPEATER X OR Y.

Each repeater has three valves, two of type LS 5B in push-pull relationship in the first stage, and a type VT25 in the second stage. The former valves, having characteristics which make them suitable for suppressing, are not, however, in the case of the transmitting line, capable of delivering the necessary output power, namely, that of the preceding repeater; and for this purpose the second stage valve is provided.

An important feature of the first stage arrangement is that the steady plate currents of the two similar valves are made to oppose one another in the split primary winding of the intervalve transformer. Hence there is no magnetic flux produced by the steady components of their plate currents; and the arrangement prevents the generation of a pulse of voltage in the transformer secondary and its application to the grid of the second stage valve when the grid priming is suddenly varied, but does not otherwise affect the performance of the repeater.

The additional grid voltage for the purpose of suppression is applied across the terminals shown as A and B in Fig. 7.

In the case of the receiving repeater X, the voltage across the above terminals AB is zero when the subscriber connected at the London end is not talking. The repeater is then properly primed at 2.8 volts and its gain is zero. Speech from this subscriber, however, produces an additional grid priming potential, the value of which remains relatively steady at about 40 volts, and the repeater thereby constitutes a loss of more than 100 T.U.

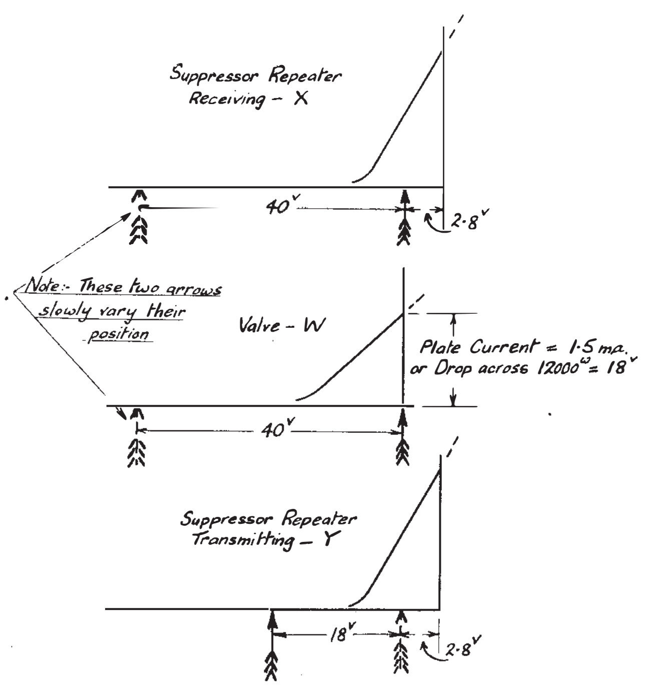


FIG. 8.—DIAGRAM SHOWING THE GRID PRIMING POTENTIALS OF SUPPRESSOR REPEATERS X AND Y AND INTERMEDIATE VALVE W. ALL FULL ARROWS OCCUR WHEN LONDON LISTENS; DOTTED WHEN LONDON SPEAKS.

In the case of the transmitting repeater Y, an additional negative potential of 18 volts, applied across the terminals AB, causes this repeater to have a loss of more than 100 T.U. when the London subscriber is not talking; speech from London, removing this additional voltage, restores the priming potential to 2.8 volts and the repeater then has a gain of zero.

It will be seen from the figure that the line windings of both input and output transformers are balanced; screens to earth are provided for the reduction of out-of-balance cross-talk effects between the lines connected to the repeater. A shunt, across the secondary of the intervalve transformer, ensures that the repeater has a transmission equivalent of zero, for all frequencies from, say, 200 cycles to 4000 cycles per second; and the repeater is designed for input power levels up to 18 T.U. above one milliwatt.

In connection with the alternate functioning of the transmitting and receiving suppressor repeaters, Y and X respectively, Fig. 8 shows their grid potential-plate current characteristic curves, and that of the valve W, which controls the operation of the former repeater. The full line arrows indicate the grid potentials when the London subscriber is silent; speech emanating from this end operates, in the first instance, simultaneously on the arrows in the two upper diagrams, and it will be seen that, when they have moved about 3 volts to the left, the receiving repeater X begins to suppress, but that approximately 1 m.a. is still passing through W, and the consequent 12 volts drop is maintaining the repeater Y in the suppressed state. For a further small movement of the two upper arrows it follows therefore that both repeaters will be in the suppressed state simultaneously, and that this transitional position to prevent singing will occur when London speaks or ceases to speak. The above figure shows also, by dotted arrows, the grid potentials when the London subscriber is actually speaking.

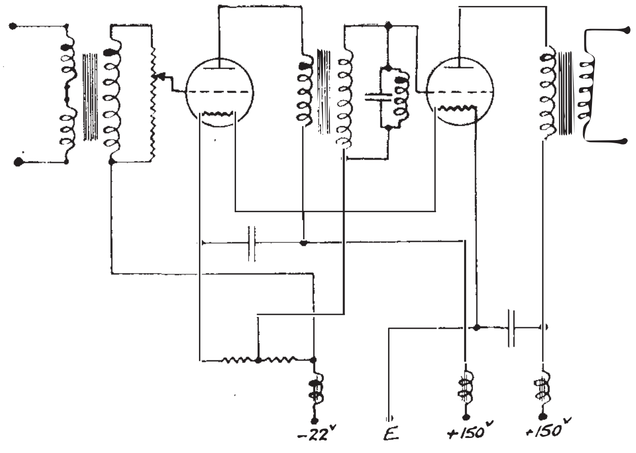


FIG. 9.—DIAGRAM OF CONNECTIONS OF AMPLIFIER P OR Q—EXCEPT THAT Q HAS NO RESONANT CIRCUIT AT INTER-STAGE.

Amplifiers P and Q.—Referring to Figs. **6** and **9**, these are provided for transmitting to R, at the points "*b*" and "*c*," the necessary magnitude of speech or other currents. Each has an input impedance of not less than 20,000 ohms and connection is made to the main "Go" and "Return" lines at the points "*a*" and "*e*" respectively, the shunting effect on the lines being of the order of one-tenth of a T.U. Furthermore, to reduce out-of-balance cross-talk effects, the primary windings of the input transformers are balanced and screened, while their ratio of transformation is such as to prevent grid overloading, and the consequent distortion of speech in the main lines. The filament and plate battery for both amplifiers is the common supply, while grid priming is obtained by utilising potential drop in the filament circuit.

The transmitting amplifier P, by means of a resonant circuit in shunt across the intervalve transformer, is designed to have a maximum gain at a frequency of 1200 cycles per second, and a potentiometer across the input enables this gain to be varied in 2 T.U. steps from + 10 T.U. to − 10 T.U. when measured at the above frequency. The greater part of the voice power from the transmitter occurs in the neighbourhood of this frequency; so that by the above tuning more efficient operation by speech of the voice operated equipment is obtained, while for a considerable proportion of land line noise, atmospherics, and some of the speech echo, the frequencies of which are remote from the above value, the device becomes insensitive. It will be noted later that another resonant circuit is introduced in the amplifier S, and it is obvious that the overall frequency characteristic from "*a*" to T mainly determines the complete operation of the device.

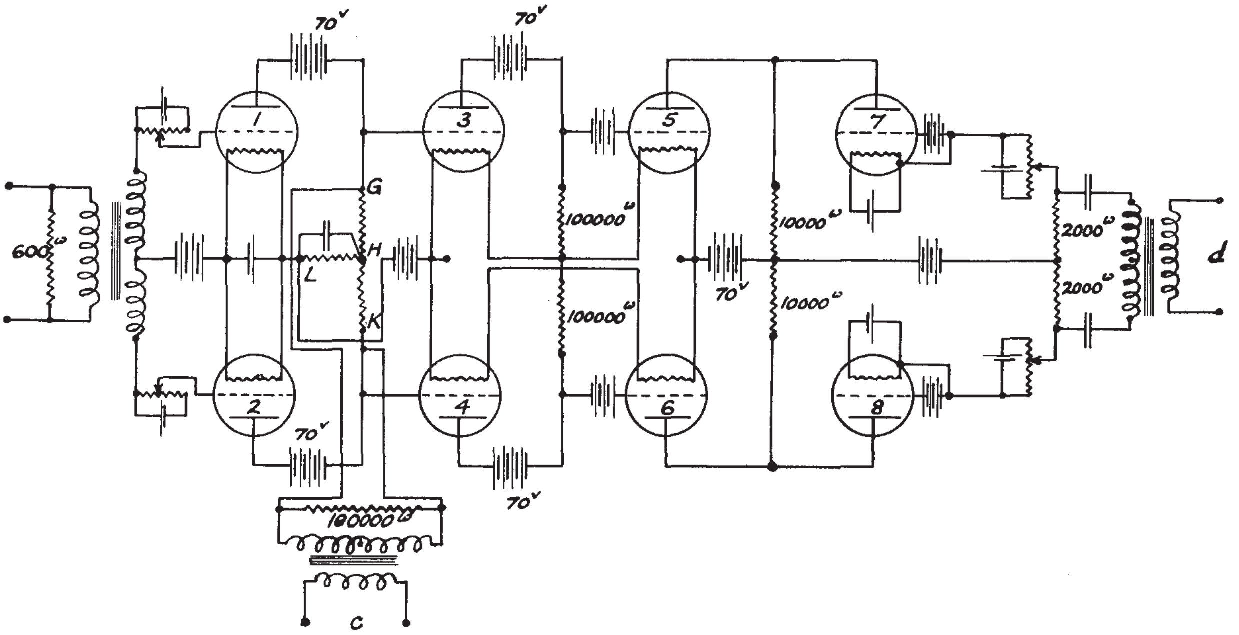


Fig. **10**.—Rectifier and High Balance System.
Valves 1, 2, 7 and 8 Type VT33. Valves 3 and 4 Type LS 5B. Valves 5 and 6 Type VT25.

The receiving amplifier Q is at present untuned, and its circuit diagram is as shown in Fig. **9**, but without the provision of the resonant circuit. The transformers in this case are designed so that by means of the potentiometer the gain of the repeater may be varied in steps of 2 T.U. from 12 T.U. to 32 T.U.

Rectifier and High Balance System.—This is shown as R in Fig. **6**, while a diagram of connections is given in Fig. **10**.

In its present form it may be regarded as comprising two rectifying valves 1 and 2 in the receiving circuit, and six valves 3 to 8 in the transmitting circuit. Valves 3 and 4 are made to function mainly as rectifiers; 5 and 6 thereby work in only one direction; while 7 and 8 are diodes made to operate as very efficient rectifiers.

At the junction GHK of the receiving and transmitting valve system, the input speech or other voltage from "*c*" is impressed, and, in the absence of any other voltage at "*b*," the former is transmitted through valves 3, 4, to 8, to the suppressing devices which are thereby operated. If, however, speech or other currents are impressed at "*b*," it will be seen that, by virtue of rectification, unidirectional current flows through LHG and LHK according as the pulse is, say, positive or negative. By this means, the grid potentials of the valves 3 and 4 become much more negative, causing these valves, and more particularly valves 7 and 8, to become to a small or large extent inoperative, depending upon the magnitude of the above biassing voltage.

Furthermore, the condenser connected across LH, when current is traversing this path, acquires a charge, and by virtue of the magnitude of the resistance LH a potential persists, which renders the transmission path from "*c*" to "*d*" inoperative both for the interval between positive and negative pulses of current at "*b*," and for a certain time after these pulses have ceased.

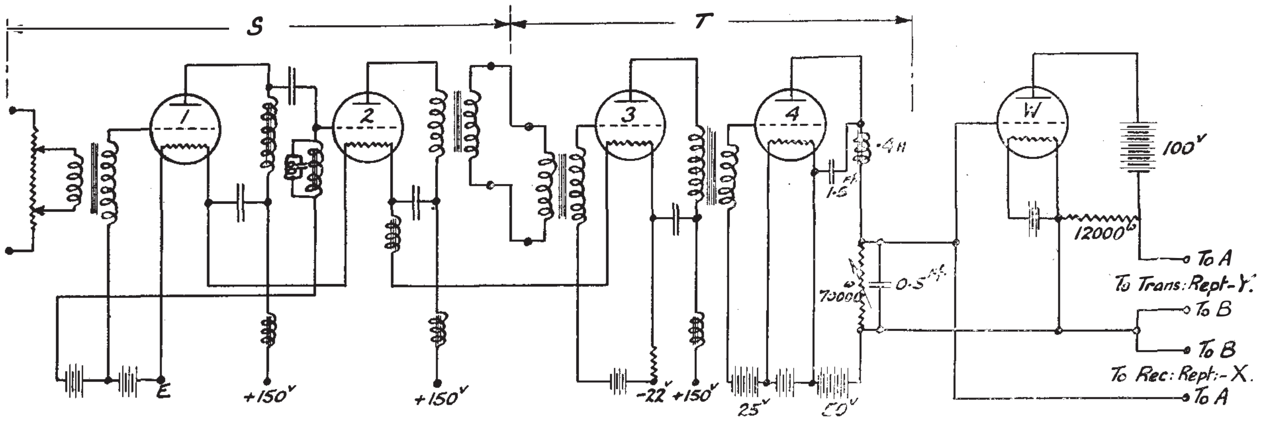


Fig. **11**.—Amplifier, Rectifier and Grid Bias Units.
Valves 1, 2, 3 and 4 Type VT25; Valve W Type DE4; See also Fig. 7.

Hence alternating currents, due to speech or noise in the return line at "*e*," in Fig. **6**, thereby impose *via* "*b*" and the resistance-condenser junction in R instantaneous, intermediate and delayed protection or bias, to prevent or retard the possibility of echo, or other noise currents which may traverse the "Go" line at C and "*a*," causing false operation of the suppressor device. It will be observed that this rectifier system functions differentially, inasmuch as the larger the currents in the return line which will cause larger echoes the greater will be the bias imposed at "*b*." At the same time, it is obviously important, in view of the great sensitivity employed in connection with voice operation, to so adjust the rectifiers, more especially 7 and 8, as to prevent any effective transmission from "*b*" to "*d*," caused by currents, however small, at "*b*." The stability and high balance in the system is assisted by a balanced and screened winding on each transformer.

In Fig. **10**, the values of the resistances GH, HK and LH are each 12,000 ohms, while the condenser across the latter is 2 microfarads. Speech on the receiving line from Wroughton with a normal setting on the amplifier Q produces an average current of one milliamp in each of the paths LHG and LHK, and the peak voltages acquired across HG and HK may be of the order of 24 volts. It will be seen therefore that, during the arrival of received speech a voltage of, say, 24 volts will be acquired across LH, and provision is made for a total maximum instantaneous bias of 48 volts, a minimum instantaneous and transitional bias of 24 volts; and, after the cessation of the speech, the discharge of the condenser through the resistance LH determines the magnitude of the delayed or echo hangover protection. The latter biassing potential, which has the initial value of approximately 24 volts, falls exponentially and it is computed that, apart from the protecting feature provided by the trailing weak parts of speech, the potential drop on LH is sufficient to prevent false operation by an echo attenuated not less than 18 T.U. when the delay of the echo is

0.025 second; or not less than 26 T.U. when the delay is 0.05 second. The amount of the attenuation of the echo is here referred to as the difference in the received volume at B, in Fig. **6**, from the 4-wire circuit and that of the echo on arrival back at the same point. Also the attenuation figures quoted refer to the most severe case; that is, when the volume at B produced by the London subscriber is 25 T.U. below reference volume, the maximum gain then being in operation in the " Go " line.

The Suppressor System.—This is shown as S, T and W in Fig. **6**, while a diagram of connections is given in Fig. **11**.

The alternating output from the rectifier system R (at " *d* ") in Fig. **6**, is applied to the input of the amplifier unit S, Fig. **11**, comprising valves 1 and 2, whence it is transmitted to the amplified rectified unit T, comprising valves 3 and 4, and, across the resistance condenser combination in the latter, a unidirectional potential is obtained.

This potential is applied to the grid circuit terminals A B of the receiving repeater X, which is thereby suppressed, the performance being similar to that employed on ordinary long distance 4-wire telephonic communication.* During the continuance of ordinary speech, the condensers operate to maintain a value of unidirectional potential which varies relatively slowly from, say, 15 volts to 40 volts, and the voltage will persist for a time after the cessation of speech from London.

When there is no speech from London, it will be seen that the grid priming potential of the valve W is zero, whence its plate current of 1.5 *m.a,* through an external resistance of 12,000 ohms, produces a drop of 18 volts, which being applied to AB of the transmitting suppressing repeater T renders the latter inoperative. Speech from this end, however, producing the potential of 15 to 40 volts stated above causes the plate current of W to fall to, and be maintained at, zero; whence, the repeater Y, losing its additional grid bias, is made to function and the speech is freely transmitted to Rugby.

In the rectifier circuit of T the resistance condenser combination and the additional inductance and condenser units, as shown in Fig. **11**, are such that the unidirectional voltage is rapidly acquired, the minimum operating time being approximately 2.5 milli-seconds, and the necessary hang-over, at present about 0.35 second, is obtained. The latter inductance and condenser units also largely perform the function of eliminating much of the alternating component of the current, while the latter unit assists the rectification.

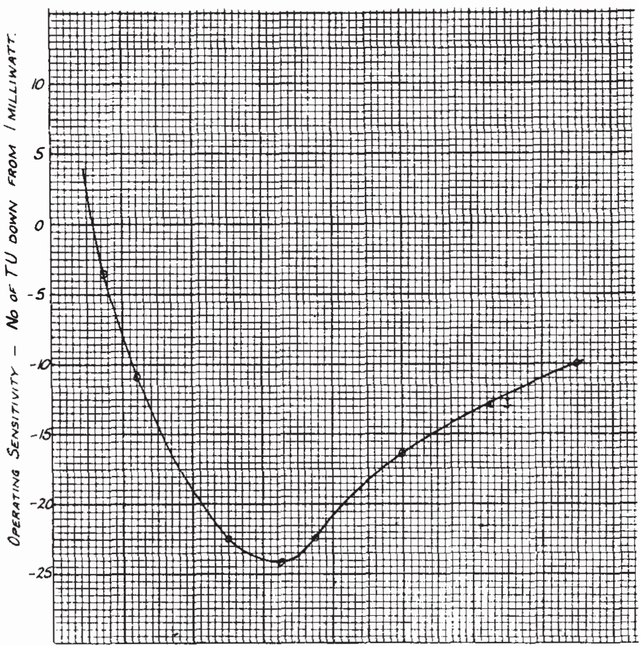


Fig. **12**.—Curve showing relative Transmitting Sensitivity measured at point B. See Fig. 6.

As stated previously, a resonant circuit is introduced in the amplifier S, and the frequency response operating in conjunction with that of the tuned amplifier P, produces the overall response shown by the curve Fig. **12**.

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* *Recent Research Work on Telephone Repeaters by C. Robinson and R. M. Chamney, I.P.O.E.E. Paper No.* 99, *page* 15.

NOTES & COMMENTS

WITH this issue of the Journal two important changes have been introduced. In the first place we have reduced the price to five shillings per volume to all annual subscribers, and secondly the size of the magazine has been altered. We do not expect to hear any objections from our readers on the first score, except that some may wish to argue that the price should have been lowered still further, to the original sum of four shillings. Our answer to this would be that we must hasten slowly, that twenty-five per cent. over 1914 figures is better than the present prices for most articles, as the cost of living indicates, and that the question of a still further reduction rests with the rank and file of the Engineering Department themselves. The position is favourable: if the Inspectors, Skilled Workmen, U.S. W.'s and youths respond to the appeals circulated to the sections, as the Board confidently hopes they will do satisfactorily and enthusiastically, the price of the Journal will be reviewed again. We have no axe to grind, no need of profit making; our sole desire is to present a record—as full and as accurate as possible—of the progress being made and the developments taking place in the art of electrical commuication both at home and abroad at a price just high enough to cover the working expenses.

We must admit to being not quite so happy and confident with regard to the second change. Those subscribers who have had their volumes bound from the start will undoubtedly have a grievance, as the uniform series in their bookshelves will be broken, but we submit that the new shape and size will permit of much better and clearer illustration, and as many of our diagrams are intricate, to say the least, the wider page will give better opportunity to spread them out and thus render them more readable than they have been in the past. It may be argued that the new size is not so suitable for the pocket, but we do not anticipate that the thickness will ever reach a size that will prevent the magazine from being folded for that purpose. The type of binding for the volume and its price will be announced in due course.

At the annual meeting of the Telephone Development Association, Sir Alexander Roger, Chairman, said the revenue for the past year was £15,962, of which 79% was spent on advertising and propaganda and 15% on administration. The membership had increased from 54 to 95. He emphasised the importance of the telephone industry and said that the capital invested in this country alone was about £80,000,000, employing 100,000 people, in addition to probably 50,00 to 60,000 engineering and operating staff.

We must return thanks for the following letter, which appeared in "The Times," on the 18th February:—

BEAUTY WITH TELEGRAPH POLES.

A little time ago you published some correspondence on "unsightly" telegraph poles. May I, very belatedly, put the other point of view? Has it not been noticed how beautiful they are, especially on the Portsmouth Road? The great black poles with their crossed bars and white cups allure one as a woodcut. They are banner-shaped and edge the long road like an exquisite border. And on a frosty night, when the traffic pours down to the coast and the moonlight shimmers on the wires all rimed with white, they are, to those who have the eyes to see, like the banners of a celestial army which is marching in triumph to the sea.—Mrs. C. M. COTTON, Great Beech, Battle.

Comment is needless. Mrs. Cotton's beautiful conception must come as balm to the soul of the engineer who built that Portsmouth Road line.

The Hon. J. C. Coates, M.C., Prime Minister of New Zealand, visited the Hendon Factory of Standard Telephones and Cables, Limited, on the 31st December, and inspected the new 5 K.W. Broadcasting Set recently manufactured there for installation at Wellington, N.Z. The apparatus was actually demonstrated, and Mr. Coates expressed keen pleasure at the purity of speech and music obtained.

A model exchange, forming part of the new Automatic Telephone System for London, was also demonstrated, and Mr. Coates was shown, and discussed, many other new and interesting aspects of the Company's activities in the advancement of speech transmision.

King Alfonso, General Primo de Rivera, together with over two hundred Government Officials, Diplomats and leading citizens of Spain, participated recently in the establishment of a new European long-distance telephone record, when a conversation was carried on over a circuit 3,800 Kilometers long, as a feature of inauguration of Standard Rotary Automatic Telephone Service throughout Madrid.

The record was established in a demonstration of the lines of the nation wide system that has been built in the last eighteen months by the Compania Telefonica Nacional de Espana and although the distance covered was equal to that from Madrid to Moscow the circuit did not extend beyond Spanish territory. It did, however, cross the Straits of Gibraltar by submarine cable uniting the Continents of Europe and Africa. Starting at Madrid, the circuit travelled north of San Sebastian on the Bay of Biscay, passing thence south-easterly to Barcelona on the Mediterranean, then turning westward to Madrid, deflected to the South and diving beneath the surface of the sea at Algeciras, brought up at Ceuta in the Spanish Protectorate of Morocco. Returning northward to Madrid by another line the circuit then shot off toward Galicia, terminating at Coruna on the north-west corner of the Iberian Peninsula. Sixteen stations responded to the roll-call over this circuit and greetings were exchanged with the four corners of Spain. The demonstration was opened with a talk by the Marques de Urquijo, President of the Company, in which he described the work accomplished in the past year. General Primo de Rivera replied in the name of the Government, expressing his appreciation and congratulating the Company on what it had accomplished for the benefit of the National communication in such a short time.

After the roll-call was completed, His Majesty addressed the sixteen stations over the circuit, congratulating the Compania Telefonica Nacional de Espana and the Spanish Nation, expressing his satisfaction upon the important advance which had been made in the Telephone service of the country.

This event was preliminary to the formal opening by King Alfonso of the new Madrid Local Telephone system completely installed in a space of fourteen months by the Compania Telefonica Nacional de Espana, the old manual switchboards and overhead lines being replaced by Standard Rotary Automatic equipment and underground cables.

The change in service was accomplished simultaneously throughout the Capital and was loudly acclaimed by the public, who had endured many years of inadequate facilities. Madrid is second in the series of nineteen cities in which the Compania Telefonica Nacional de Espana will convert the telephone service to Rotary Automatic within the coming three years.

Mayor's Parlour,
Southwark Town Hall,
Walworth Road, S.E.17.
15th February, 1927.

The Editor,
Post Office Electrical Engineers' Journal.

Dear Sir,

Will you kindly permit me to invite the interest of your readers in the following:—

The progress of electrical science and industry in the past century is founded largely upon the results of the labours of the illustrious natural philosopher, Michael Faraday, whose experimental researches and discoveries opened wider the power-houses of nature and pointed the way to the utilisation of the forces stored therein, as evidenced by the present universal application of them, particularly electricity in the service of mankind, and who, in the words of Sir Oliver Lodge, initiated a whole new profession—Electrical Engineering, while Sir Richard Gregory, in a recent presidential address, declared that "every dynamo in the world owes its origin to Faraday." In his life time he was described as "our great Electrician."

Michael Faraday, to whom the world thus owes so large a debt of gratitude, was born in Southwark, the son of a blacksmith whose forge stood near the well-known local landmark, the "Elephant and Castle."

To commemorate this great pioneer worker, who, in the world of science, holds a place almost equivalent to that of Shakespeare in the world of literature, the Southwark Borough Council desire to form a special collection of standard and current literature on electrical and allied sciences in the Central Reference Library of the borough, which is situated close to the spot where the forge stood.

It is suggested that the Memorial shall include also a bust of Faraday.

The use of the library is not limited to local residents, but, like the benefits of Faraday's discoveries is open to all. Moreover, it is centrally and conveniently situated near the junction of all the main thoroughfares of populous South London converging upon the principal London bridges; and it is well used—there was an issue of over 100,000 volumes last year.

It is proposed to create a Faraday Memorial Library Fund, the income from which would be expended in the acquisition of the best new books year by year and so keep the Memorial Collection always abreast of developments in, and practical application of the sciences for which Faraday did so much.

The Council would welcome the co-operation of electricians and scientists generally, many of whom it is believed would be glad to know of this opportunity to assist, if only in a small measure, in establishing in Faraday's native borough a memorial that will be worthy, permanent and increasingly useful in character.

The year 1927 has been described as the "Dawn of Britain's Electrical Age," and the time would thus seem appropriate to pay tribute to the memory of the man who made the "Electrical Age" possible.

The project has the interest and generous support of, among others, The Royal Society, The Royal Institution, Messrs. Benn Brothers, The British Electrical and Allied Manufacturers' Association, The Eastern Telegraph Co., The British Thomson-Houston Co., The General Electric Co., The Western Union Telegraph Co., Provincial Tramways Co., Ltd., Messrs. J. Dewrance & Co., Ltd., The County of London Electric Supply Co., The City of London Electric Light Co., The Edison Swan Electric Co., Messrs. W. H. Willcox & Co., Ltd., Sir R. A. Hadfield, Bart., F.R.S., and a number of private individuals.

I shall be happy to acknowledge any contributions which may be sent to the Town Hall, Walworth Road, S.E.17.

Believe me,
Yours faithfully,
W. Hewitt,
Mayor.

HEADQUARTERS NOTES.

PAPERS READ AT THE PARENT INSTITUTION

Mr. G. F. O'dell read a paper on the 2nd December on "An Outline of the Trunking Aspect of Automatic Telephony," and repeated it before the North Western and North Eastern Centres later. We hope to be able to give a summary of this valuable paper in an early issue of this Journal.

Another paper of outstanding interest was one on "Some Notes on Design Details of a High Power Radio Telegraphic Transmitter using Thermionic Valves," contributed by R. V. Hansford and H. Faulkner and read before the Wireless Section on the 1st December.

EXCHANGE DEVELOPMENTS.

Following works have been completed:—

Exchange.	Type.	No. of Lines.
Torquay	New Auto.	1280
Coventry	,,	3100
Foleshill	,,	500
Cosham	,,	160
Marlow	Auto. Extn.	80
Popesgrove	New Manual.	1360
Letchworth	,,	540
Slough	,,	550
Clerkenwell	Manual Extn.	560
Kingston	,,	1680
Royal (London)	,,	2300
Sydenham	,,	1580
Douglas (Glasgow)	,,	1820
Brixton	,,	1480
Leamington	,,	380
Park (London)	,,	2500
Clissold	,,	2750
Midland (Birmingham)	,,	2050
Leeds Trunk	,,	Trunk Section.
Glasgow Corporation	P.A.B.X.	400
Garrould's	,,	50
Bowater's	,,	30
Shell Mex (Leeds)	,,	30
Anchor Cable Coy.	,,	60
Hampton's	,,	30
Lewis (Manchester)	,,	70
Gardner's	,,	60
United Dairy's	,,	50
Bristol Docks	,,	60
Albright & Wilson	,,	40
International Combustion	,,	70
Jas. Hare	,,	30
Crawford's	,,	60
Barnsley Co-op.	,,	40
Van Moppe's	,,	30
Simpson & Coy.	,,	20
Heaton's Ltd.	,,	30
Barrow, Hepburn & Gale	,,	60
Moss Gear Coy.	,,	40
Clyde Valley	,,	60
Wiggins, Ltd.	,,	40
North of England Indemnity	,,	20
Bootle Corporation	,,	50
Liverpool Corporation	,,	60
Parkinson's Stove Coy.	,,	30
Bevin & Sons	,,	30
Stott & Smith's	,,	30
Kingseat Hospital	,,	40
Morrison's, Ltd.	,,	30
Crabtree's	,,	40
Shell Mex (Leicester)	,,	30
Archdale & Coy.	,,	30
Earl of Dudley	,,	70
Greenock Corporation	,,	80
Southend Council	,,	70
Crawford's, Ltd.	,,	60

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
St. Marychurch	Auto.	320
Forestfach	,,	150
Rochdale	,,	2000
Middlesbro' Area (4)	,,	4200
Walsall	,,	1740
Bloxwich	,,	230
Bath Area (3)	,,	3450
Bermondsey	,,	2600
Beckenham	,,	3000
Kensington	,,	10000
Fleet	Manual.	520
Dunlop Rubber Coy.	P.A.B.X.	80
Crabtree (Walsall)	,,	40
Crawford's (London)	,,	60
Dewhurst, Ltd.	,,	30
Kaye, Sons & Coy.	,,	60
Archdale & Coy.	,,	30
Blackburn Infirmary	,,	30
Morrison's & Coy.	,,	30
Britannia Assn.	,,	40
Reading Guardians	,,	30
Illustrated London News	,,	70
Royal Arsenal Co-op.	,,	60
Macclesfield Co-op.	,,	50
Dorset Council	,,	60
British Xylonite Extn.	,,	10
Midland Bank	,,	700
Carpet Manufactures	,,	40
Hove Council	,,	50
Newcastle-on-Tyne Corporation	,,	130
Shell Mex (Birmingham)	,,	50
Middlesborough Co-op.	,,	20

Orders have been placed for extension to existing Equipments as follows.—

Exchange.	Type.	No. of Lines.
Sherwood, Notts	Auto.	680
Arkwright Street, Notts	,,	500
Epsom	,,	300
Buckhurst	Manual.	480
Sloane M.F.	,,	—
Worcester	,,	720
Malvern	,,	200
Riverside	,,	1380
Finchley	,,	1740

LONDON DISTRICT NOTES.

DURING the quarter ended 31st December, the nett increase in the number of Exchange lines and extensions was 9,324.

MILEAGE STATISTICS.

During the three months ended 31st December, 1926, the following changes have occurred :

Telegraphs.—A nett decrease in open wire of 16 miles.

Telephones (Exchange).—A nett decrease in open wire (including Aerial Cable) of 240 miles and a nett increase in underground of 105,430 miles.

Telephones (Trunk).—A nett decrease in open wire of 9 miles and a nett increase in underground of 291 miles.

Pole Line.—A nett increase of 85 miles, the total to date being 5,634 miles.

Pipe Line.—A nett increase of 670 miles, the total to date being 7,903 miles.

The total single wire mileages at the end of the period under review were :—

Telegraphs	24,604
Telephones (Exchanges)	1,906,890
Telephones (Trunks) ...	64,135
Spares	93,596

INTERNAL CONSTRUCTION.

The transfer of the Epsom Manual work from Sutton to Streatham took place on January 22nd last. The equipment made spare at Sutton will be valuable for extension purposes.

An extension of the multiple at Enfield by 1,100 and the answering equipment by 760 was commenced on January 11th. This work is being carried out by the General Electric Co.

Paddington Extension of 1060 answering equipment and 1000 multiple has been started, and is being carried out by Standard Telephones and Cable Co.

Wallington New Exchange is nearing completion and will be opened on March 16th with an equipment for 3000 lines. The Exchange is a No. 1 C.B. type and has been installed by the General Electric Co. 297 lines will be transferred from Sutton Exchange coincident with the opening of the new exchange.

Streatham : An extension of 2480 is in hand, a portion of which was completed in November, and a further instalment will be completed about the end of February.

The work of installing the New Toll Exchange is proceeding and is being carried out by the Standard Telephones and Cable Company.

Considerable progress is being made with the installation of Holborn, Mechanical Tandem, Bishopsgate, and Sloane Exchanges. In addition, the installation of the New Auto Exchange at Monument has been commenced. The work at Holborn Tandem is nearing completion and 53 positions are under test by the Department in conjunction with the associated C.C.I. Equipment at the existing manual exchanges. The provision and testing out of the equipment at 5 exchanges have been completed.

TELEGRAPHS.

C.T.O.—The strengthening of the walls, precedent to the erection of a fifth floor at the C.T.O., has been completed. Extensive shifts of tubes, telegraphs, telephones and common services have been involved, in order to make space for the thickened walls, stanchions, etc. The opportunity has been taken to straighten out the routes of the tubes, and brass has replaced lead in several instances.

Clocks for Post Office Tube Railway.—The C.T.O. Section is installing a system of Electric Clocks throughout the Post Office Tube Railway System. The number of clocks to be fitted is 32, including two Master Clocks. The two Master Clocks will be fitted in the Control Room on the 2nd Floor at Mount Pleasant, and will be wired to a change-over switch to give facilities for either Master Clock to be used at will.

These Master Clocks in turn will actuate 8 Standard B. Relays (joined in series), one of which will be fitted at each station. Each relay, together with a Condenser and resistance coil of suitable value, is contained in a small case and is fitted in the Control Cabin on each platform.

The clocks on the platforms will be wired to the local contacts of the above relays, and an impulse will be given to the clocks each half minute. All wiring is Cable V.I.R. .002, and is contained in steel conduit, the power being supplied from local batteries at each platform.

The clocks are distributed in the following manner:—

(1) King Edward Street, Western Central District Office and Mount Pleasant: one 12″ and four 24″ clocks each; the 12″ clock is placed in the Control Cabin and two 24″ clocks on both Eastbound and Westbound platforms.

(2) Eastern District Office and Liverpool Street Station: one 12″ clock in the Control Cabin and two 24″ clocks on Westbound platform.

(3) Western District Office, Western Parcels Office and Paddington Station: one 12″ clock in the Control Cabin and two 24″ clocks on the Eastbound platform.

The current required to operate the relays is 16 m.a. and that for the platform clocks 300 m.a.

Batteries.—The bulk of the London District battery renewals and installations are now carried out by the Staff of the C.T.O. Section, and work is now in hand to provide for duplicate batteries at all Exchanges and also for the necessary additional capacity to meet the new requirements. The battery parts supplied by Contractors include plates, separators, etc., of standard sizes, and wood lead-lined boxes of suitable dimensions, the work of making the connection lugs, battery stands, burning plates into sections and alterations to switching gear being done by the C.T.O. Staff.

During the past twelve months batteries have been installed to a capacity of approximately 3,500 kilowatts, and work is now in hand for the installation of batteries to a capacity of 1,300 kilowatts.

Wireless.—The Canadian Beam Station at the C.T.O. is now in full swing, and consists of Wheatstone with Creed apparatus of the modern airless type. The Australian beam apparatus is ready, as far as the Post Office is concerned, but the trial has not yet been completed. These, and other wireless extensions, have rendered it necessary to double the floor-space originally occupied by the Central Radio Office. The operating does not present any unusual feature, except that a telegraphist may "get his own marks" on a loud-speaker to enable him to be certain that the signals are being relayed effectively.

Start-Stop Apparatus.—In addition to the increasing numbers of Teletypes, start-stop apparatus of the Creed type is being introduced. This apparatus is already in use on the Norwich and Newmarket circuits and is being tried on a private "A" to "A" wire. The appearance of the column-printed copy is very good, but the apparatus is, necessarily, more or less experimental.

R.A.W.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1926-27 (SECOND HALF).

What might be regarded as the second half of the session was opened on January 11th, when Mr. R. T. Robinson read a paper entitled "Motor Transport in the Engineering Department." The paper dealt with the growth of Motor Transport in the Engineering Department from the earliest days and showed by means of numerous slides, curves and figures how simple the control of the transport organisation has become. Mr. H. Wilson (Superintending Engineer, South Wales) was in town and gave us the benefit of his District experiences.

On the 8th February, Mr. W. Cruickshank gave a highly interesting and instructive contribution on "Voice Frequency Telegraphs." The paper provided an exhaustive survey of Voice Frequency Systems covering voltages, lines, methods of operating, signal codes and shapes, the disturbing effects of telegraph signals on telephone pairs, and a description of trials carried out in such far places as Germany, Czecho-Slovakia, America and Japan. A keen discussion followed, in the course of which representative opinions were obtained from members of the International Electric Corporation and the General Electric Company.

On the 8th March, the Vice-Chairman (Mr. J. W. Atkinson) gave a valuable discourse on

"A Short History of the Post Office Engineering Department." The author, in the course of his remarks, pleaded for the preparation of a concise history of the Engineering Department, preferably in narrative form with that dash of humour which would enable an easy divorce from ponderous official phraseology to be achieved. The paper covered the whole growth of the Engineering Department from its inception and showed how the taking over of the various Telegraph and Telephone organisations culminating in that of the National Telephone Co.—veritably the sprat "taking over" the mackerel—affected the growth of the staff, and, incidentally, the Engineer-in-Chief's salary, the increase in the latter, however, bearing no relation whatever to the former. The names of many illustrious men were mentioned and the value of their work for the Department appraised. A good discussion followed.

The Informal Meetings are still proving to be good "draws." The third meeting of the series was held on January 25th, when Mr. James Cowie opened a discussion on "Training for Management." Mr. Cowie's inimitable Scottish manner and the humour of his remarks made one realise why his compatriot, Harry Lauder, is enabled to run mansions, motor cars and knighthoods at the public expense. An excellent discussion rounded off a delightful evening.

The fourth Informal Meeting took place on February 22nd, when Mr. T. Hargreaves, before a large assembly, opened a discussion on "Staff Problems and Efficiency." The author tackled his question fearlessly and there was a spirited discussion.

Arrangements were made for visits to the Holloway Factory on the 11th, 12th and 13th January, three days being necessary as the number of members wishing to attend was so large. The parties were looked after in a manner which reflected great credit upon the officers of the Stores Department and the Committee would like to take the opportunity of thanking the Controller and his staff for the excellent programme arranged.

It is proposed to visit the Lighting Service Bureau of the Electric Lamp Manufacturers Association in the middle of March.

F.W.F.

SOUTH MIDLAND CENTRE.

The attendance at the opening meeting of the 1926-7 Session, held on the 27th October, 1926, numbered 68.

The Chairman offered Mr. J. C. Eaton the best wishes of the members of the Centre for happiness in his retirement and Major Harris eulogized Mr. Eaton's work in the Oxford Section. Mr. Eaton acknowledged the felicitations.

Mr. J. E. Taylor, the Chairman of the Centre, read a paper "The Theory of the Electric Current. An Historical Survey." The lecturer in preliminary remarks announced that the opinions to be given were frequently unorthodox and that it therefore behoved his audience not to be too easily influenced by them.

It was explained that, previous to Faraday's work, there was a belief in an electric fluid and also a magnetic fluid which produces magnetism. These views were, however, dispelled by Faraday, who originated the "lines of force" view which emphasised the primary importance of the di-electric medium. Maxwell's contribution and his introduction of the conception of "displacement current" were elucidated, together with some reference to Lord Kelvin's views on the theory of transmission along cables. Professor Poynting's theory of the electrical transfer of energy was the next to be explained and this was followed by an exposition of Sir J. J. Thomson's view that the electron is not the final limit of disintegration.

The views of the late Oliver Heaviside were then discussed at greater length and the lecturer expressed the opinion, which appears to coincide with Heaviside's ideas, that there was no fundamental difference between displacement currents in the ether and currents in conductors. It was pointed out that the electronic theory of currents in conductors was strongly deprecated by Heaviside and considered by him to be a retrograde view.

The lecturer finally touched on the point as to whether Ohm's Law could be regarded as a representation of something which really occurred, or whether it was merely true mathematically but not physically. The lecturer took the position that, as a physical representation of fact, it was erroneous and misleading.

Replies were given to the questions asked by the Vice-Chairman, Messrs. Atkins, Lewis and Lines, and the Vice-Chairman in thanking the lecturer on behalf of the members made reference to the honour done to the Centre by the reading of a paper of so high an order.

On the 24th November 61 members and visitors heard a paper entitled "Local Line Plant Economics," prepared by Mr. H. Kitchen, read by Mr. W. B. Crompton, who is also on the Staff of Engineer-in-Chief's Office.

It was pointed out that the annual expenditure on local line plant, which amounts had been rising for some years, was increasing at a rate faster than the revenue and some effects of the provision of wires and ducts in advance of requirements were explained.

The cost of laying the various types of conduits used by the Department were compared and the possibilities of utilizing boring apparatus explored. The planning necessary before a contract for underground work is let was detailed and the importance of these preliminary arrangements emphasised. Teeing systems received consideration at some length and various proposals were demonstrated on the screen. The economies which follow the provision of composite cables were set out and a new type of "quad" paper core cable described.

The lecturer passed on to show the savings which could be effected by employing an Ingersoll-Rand outfit for erecting poles where the ground was suitable. The principles influencing the decision whether the provision of open or of underground conductors was the more desirable were enunciated. The closing chapters of the paper were devoted to the consideration of the amount of plant which should be provided in Multi-office, Automatic, new Exchange and existing Exchange areas.

Numerous questions were put to the lecturer and opinions expressed by Mr. Halton, Major Harris and Mr. Dwyer, and after Mr. Crompton had replied the Chairman thanked him on behalf of the audience.

A.W.L.

NORTH EASTERN CENTRE.

The 1926/7 Session opened on the 12th October by Mr. J. T. Tattersall, the Executive Engineer stationed at Hull, who gave an interesting survey of the History and Telephone Development of Hull, and as the local telephone service at Hull is still in the control of the Corporation, it will readily be imagined that the reading of the paper was followed very closely.

The members who had been transferred from the National Telephone Company mentally compared the conditions obtaining in the "good old days" and found that the comparison did not justify the "good" and came to the conclusion that the present was better than the past and the best was yet to be—whilst the P.O. men were amazed at the tactics employed in the early days of telephone competition and consequent upon their rigid training in the school of "safety first" longed for the authority to display their initiative, which authority they knew could not be given.

The evening provided an interesting study to the student of human nature, proving that human nature generally wants what it has never had and, when it gets it, longs for the good old days when it hadn't it.

The November meeting was favoured with a visit from Mr. Crompton, of the Engineer-in-Chief's Office, and these visits of the gentlemen from Headquarters are always the most interesting of the Session, consequent upon

(1) the expert touch,
(2) the decisive method of dealing with questions consequent upon (1),
(3) the appearance in the flesh of "paper" men whom the majority have known for years.

No. 3 often comes as a shock.

Who would have ever imagined the signature of—well, I won't say who, but it is quite a thin weedy signature—had behind it a voice like rolling thunder amongst the hills, whilst another signature, giving one the impression of rolling thunder, has behind it the shrillness and perkiness of the cock sparrow in spring, and so on and so on.

Mr. Crompton was no exception to (1) and (2) and his paper on "Local Line Plant Economics" supplied information which was being sought in many round-about ways; he collects the rivulets of information; takes out the mud gathered on the way and presents a full flow of clear crystal knowledge. The visit was much appreciated and Mr. Crompton was no doubt repaid by the keen interest displayed by all present.

The December meeting was a happy continuation of Mr. Crompton's subject by Mr. G.

Bailey, late of the Northern District, but presented with the tongue of the Tynesider joyfully lilting off words many of which did not "get over" at first throw. His subject was "The Preparation of Underground Development Schemes and Suggestions *re* Lay-out," and was dealt with in the typically northern shrewd manner, much to the enjoyment of all present.

Our meetings are becoming more helpful each Session, and one of the most pleasing features is that practically all members feel quite at home in the discussions and readily bring forward any difficulty they have experienced touching on the subject under discussion.

SCOTLAND WEST CENTRE.

The second fixture for Session 1926-27 was reached on 1st November, when Mr. M. McKenzie delivered a paper on "Main and Local Overhead and Cable Records."

The paper dealt exhaustively with the whole of the Department's records of line plant, details being illustrated by lantern slides. The Department's machinery for keeping its records up-to-date was fully described and the difficulties encountered in obtaining and recording the necessary information were outlined by the lecturer. Instances were quoted where, especially in regard to pole diagrams, the instructions were not closely adhered to and resulted in unnecessary work. The instructions regarding such cases were explained and illustrated on the screen. The lecturer expressed his indebtedness to Messrs. Dacombe and Donellan, of the North Wales Centre, for the assistance contributed by the loan of their paper on "Plant Records."

A long and interesting discussion followed the delivery of the paper, in the course of which many points were brought up and dealt with by the lecturer.

The third fixture for this session took place on 6th December, the lecturer for the day being Mr. A. Arnold, who took for his subject "A Description of working 4-Wire Trunk Circuits from Glasgow Trunk Exchange."

The attendance of visitors from other Departments was indicative of considerable interest.

The lecturer first of all explained the necessity for the introduction of the 4-wire system and then, with the assistance of lantern slides, developed the subject. The ringing difficulty on 2-wire, echo effect on 4-wire and the means for its suppression, the reed armature and other features of the system were fully explained and illustrated. Repeater diagrams at intermediate points were also shown and traced out. Some of the slides used were loaned from Mr. Jones, of Fenny Stratford Repeater Station, and the lecturer expressed his thanks to Mr. Jones for the facilities.

A large number of questions were put by the members and visitors and to these the lecturer replied.

The fourth meeting for the current session was held in the Royal Technical College, Glasgow, on 17th January, when Mr. Aitken presided over a good attendance. The programme card indicated Mr. H. Kitchen, of the Engineer-in-Chief's Office, as the lecturer for the day on the subject of "Local Line Plant Economies," but, owing to unavoidable circumstances, Mr. Kitchen was unable to be present. His place, however, was ably filled by Mr. W. B. Crompton, of the Local Lines Section of the Engineer-in-Chief's Office.

Most readers of the Journal will be conversant with the contents of the paper, as it has been delivered before several Centres.

A long and interesting discussion followed the reading of the paper and the meeting terminated with a hearty vote of thanks to Mr. Crompton.

NORTHERN CENTRE.

At the third meeting of the Session, held on the 15th December last, a paper entitled "Wayleaves and Relative Difficulties," was read by Mr. B. Miller.

The author outlined in an apt and concise manner the various Acts of Parliament relating to telegraphs passed since 1836, and explained fully the Postmaster-General's statutory powers and how those powers were derived. He then gave an interesting history of the status and control of roads.

Before dealing with the difficulties met with in exercising the Postmaster-General's statutory powers, a resumé of the procedure followed in a Sectional Engineer's office for obtaining any consent was given, together with an appendix setting forth the whole of the forms required in connection with wayleaves and the circumstances in which each form is used.

The many pitfalls waiting for the unwary were pointed out and ways of avoiding them indicated. The importance of duly observing the Postmaster-General's statutory obligations was emphasised.

In the course of the paper several suggestions relating to the placing of plant in streets and roads and on railways, etc., and the attachment of wireless aerials to the Department's poles, were made with a view to expediting the Department's business. Although the adoption of some of the suggestions would involve further legislation, it was thought that the end would justify the means.

The comprehensiveness of the paper was freely commented upon in a well sustained discussion, the opinion being expressed that the information furnished would be helpful to the Staff and that the paper would be useful for reference purposes.

Disappointment was felt because of the inability of Mr. H. Kitchen, late of the Northern District and now in the Engineer-in-Chief's Office, to deliver personally his paper on " Local Line Plant Economics " at our January meeting, but the welcome given by 82 members to his capable substitute, Mr. W. B. Crompton, was none the less hearty. The paper was taken as read and Mr. Crompton's introduction of the paper and description of the lantern slides was followed by a brisk and spirited discussion. Eleven members participated in the discussion and several others were prevented from making contributions owing to the application of the closure by the Chairman due to time considerations. The parts of the paper which were subject to most comment and criticism were those dealing with the relation of Revenue to Capital Expenditure, the Teeing system described in the paper, the furnishing of development figures, the limiting of resistance for local exchanges, the use of aerial cable and the carrying out of duct work by the Department's own staff. Mr. Crompton dealt with the points raised in the discussion, his advocacy of the proposed Teeing system whereby a group of D.P.'s is formed, each D.P. being either directly or indirectly interconnected with the others in the group by means of teeing so as to form the equivalent of one large D.P., being a strong feature.

Mr. J. Brown's paper on "Local Underground and Open Line Faults—Their Detection and Clearance," which was read on the 16th February, proved to be popular and was well discussed. The paper enumerated defects frequently met with in open line construction and in laying underground cables which give rise to faults, and useful preventative measures were suggested.

The visit to Cowgate Repeater Station, Newcastle, arranged for the 23rd February, has been postponed.

Three Associate Members, Messrs. H. Fisher, C. W. Hall and F. Bell, have retired from the service under the age limit during the last two months.

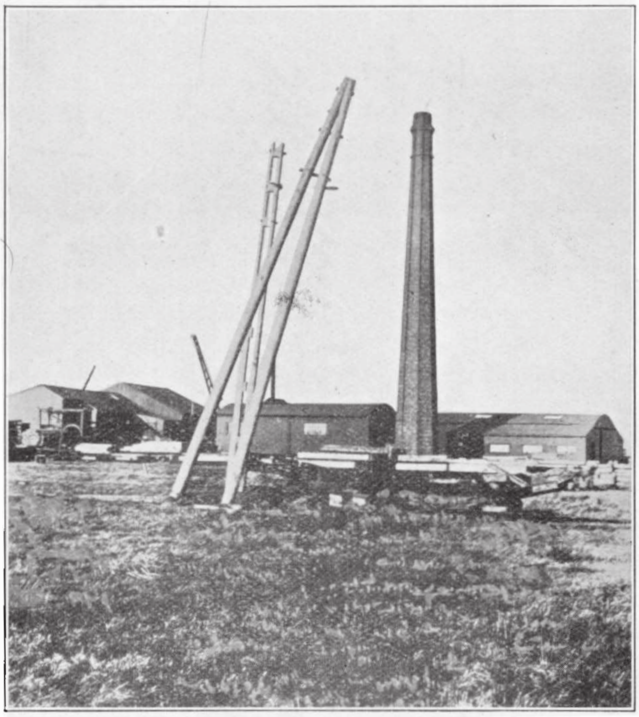
NORTH EASTERN CENTRE.

The second half of our programme opened on January 11th, 1927, when Mr. W. V. Ryder, M.I.E.E., read a paper on " Impressions of the Engineer-in-Chief's Automatic Training School," making it clear that the School met a real need and proving that the organisation was of the most efficient character. High tribute was paid to the instructors' abilities and patience, and every member of the meeting who had attended the School confirmed the excellent impressions gained by Mr. Ryder during his visit.

On February 9th another phase of the Institution's activities was entered upon.

In Leeds there is a " Cinema Exchange " where, in a well appointed room, Trade shows are given to advertise the films on the market. These trade shows are not given every day, but only twice or thrice per week and therefore on the other days of the week the " operating theatre " is available for outsiders to make use of, and for the information of those Centres who have not yet engaged such a room the charge made is £1 1s. 0d. per hour inclusive of room and operator.

Mr. J. Shea, M.I.E.E., had obtained a film from The Equipment and Engineering Co., who are the suppliers of the Simplex Pole Lifting Jack, and this film was shown as part of Mr. Shea's paper on " Overhead Construction." The film clearly showed men at work with the Lifting Jack—(1) fixing the Jack in position, (2) attachment of chain to pole, (3) men working the Jack, (4) the pole gradually being pulled direct out of the ground, (5) the use of guy ropes, (6) the fall of the post, the whole operation being a startling revelation of the advance made in the method of recovering poles, and proved that in a large percentage of pole recoveries, a remarkable saving in labour is effected by the use of the jack. A continuation of the film showed the working of the pole loading gear which has been fitted to one of the Department's 3-ton Albion lorries, and the facility with which poles were loaded on to the lorry and readily placed in position made one appreciate to the full what great advantages lie in mechanical contrivances which reduce manual labour to a minimum and at the same time deal more expeditiously with heavy loads.



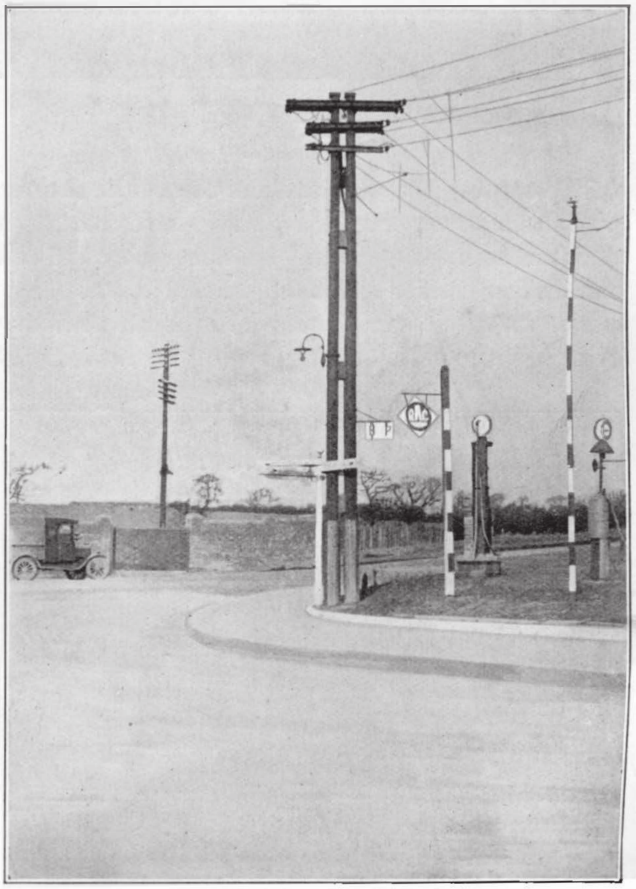
THE RUTTER POLE, COMPARATIVE TEST.

During the showing of the films Mr. Shea, in his characteristic manner and consequent upon his wide and varied experience on overhead construction, made running comments which added greatly to the fuller appreciation of the several operations depicted on the films.

Then followed a series of slides showing different structures, etc., which had come under Mr. Shea's special notice and a few of these will be specially interesting.

The Rutter Pole (*Patented*).—This photo show the result of a test made between an ordinary A pole and the Rutter. With a pull of 14½ cwt. one leg of the A pole gave way but the Rutter pole only gave very little, as will be seen from the photo, when the pull reached 31½ cwt. Both poles had been in position 6 months at the time the test was made.

	A Pole.	*Rutter Pole.*
Ground Line ...	11¾″	9½″
Depth in ground...	6′	6′
Height of pole ...	40′	40′

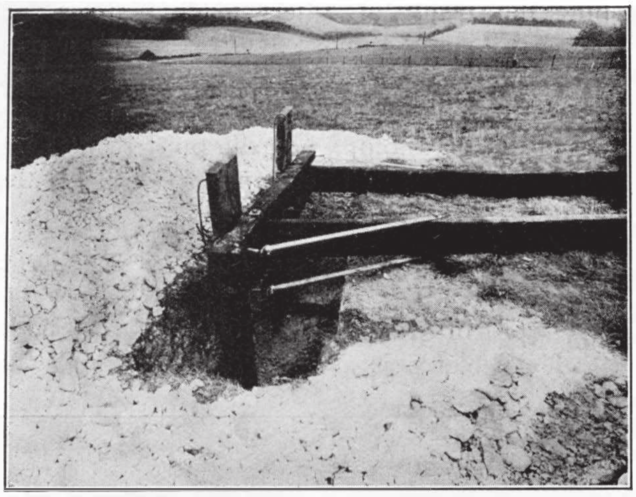


RUTTER POLE AT ANGLE.

The advantages claimed for the Rutter pole may be summarised as follows:—

(*a*) Size for size stronger than any other pole yet designed.
(*b*) Take up less ground space.
(*c*) Less excavation necessary.
(*d*) Neater in appearance.

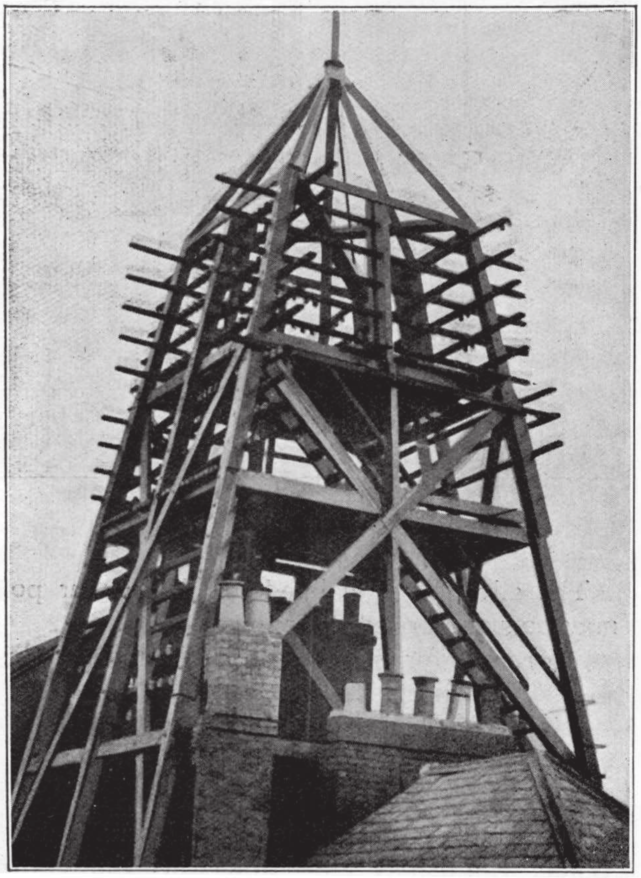
The Rutter is obtainable from Messrs. Gabriel Wade, English & C., Hull, who kindly furnished the details of test and the photo.



Patent Anchor A Pole.

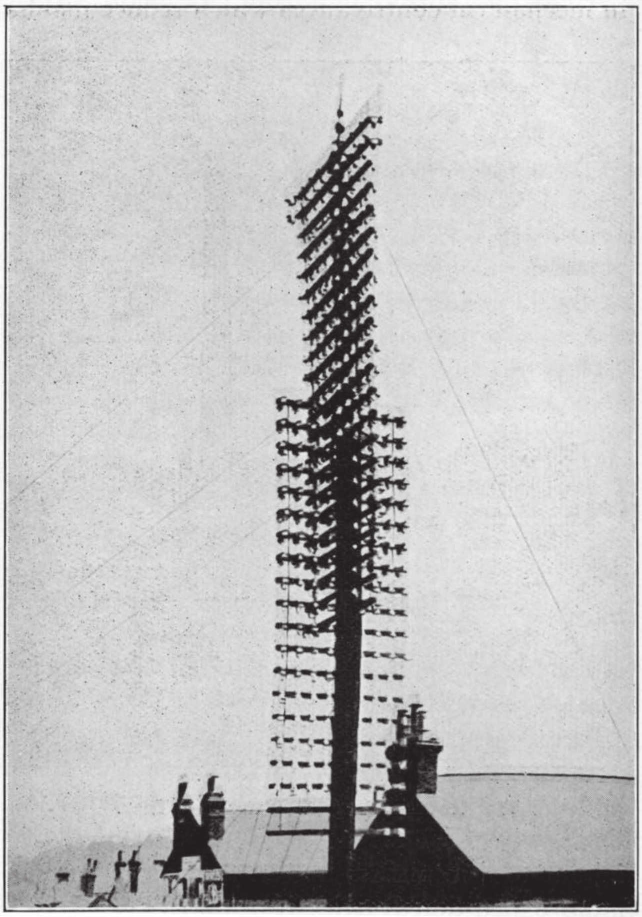
The second photo shows the use of the Rutter pole for a power line at a point where there is a definite right-angle pull on the pole and its stability is clearly indicated in the photo.

Patent Anchor A Pole.—This is an ordinary A pole with special strengthening at the foundation. It stood the test of 70 cwt. as against 15 cwt., the maximum of an ordinary pole. This patent pole is claimed to be as efficient as A poles set in concrete, without the added expenditure. The patent is one of Messrs. The Electrical Improvements, Ltd. The photo is one supplied by Messrs. W. T. Henleys.



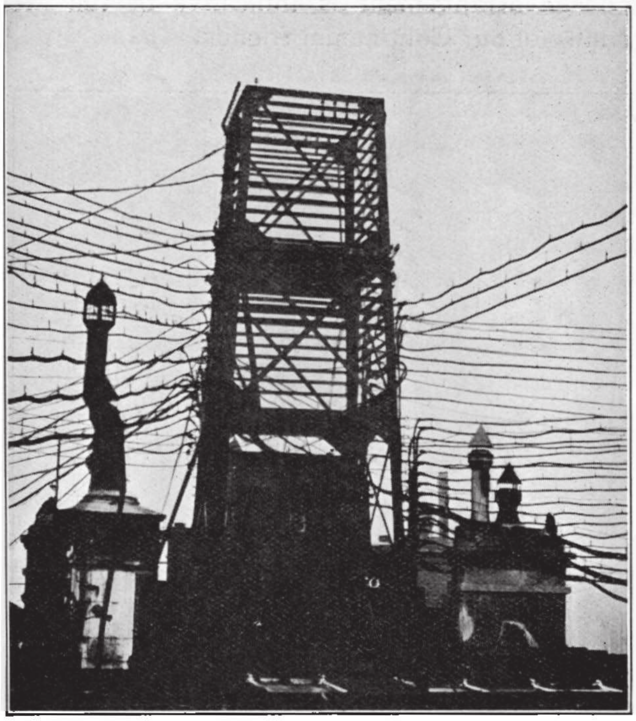
Sunderland Exchange Derrick.

Sunderland Exchange Derrick.—Erected about 1888; cost said to be approx. £600. This is a most unusual structure and from the appearance it will readily be understood that other than telegraph engineers had a hand in the construction; as a matter of fact, it was built by a firm of local shipwrights and was built for all time. The winds blew, the rains fell and beat upon this structure and it fell not, for it was built like a rock!

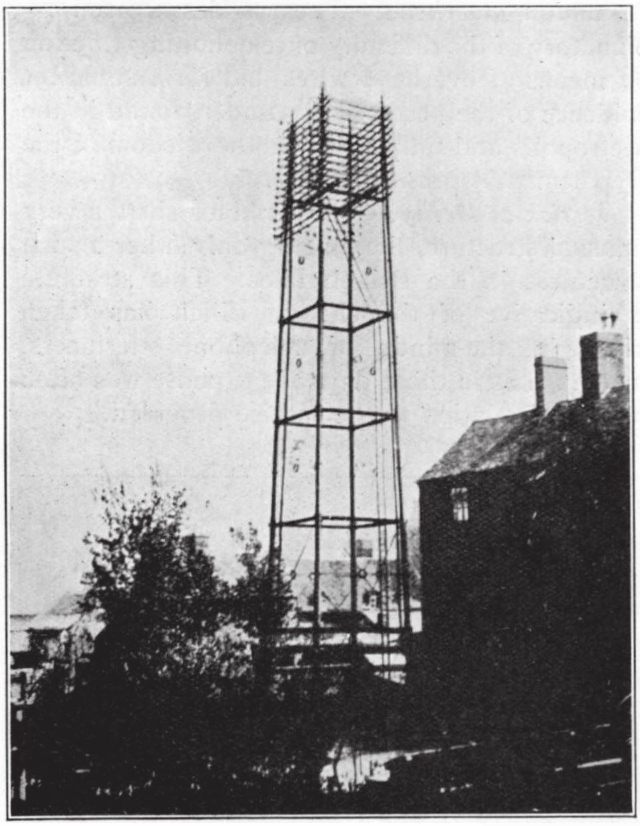


A D.P. (not in the N.E. Dist.).

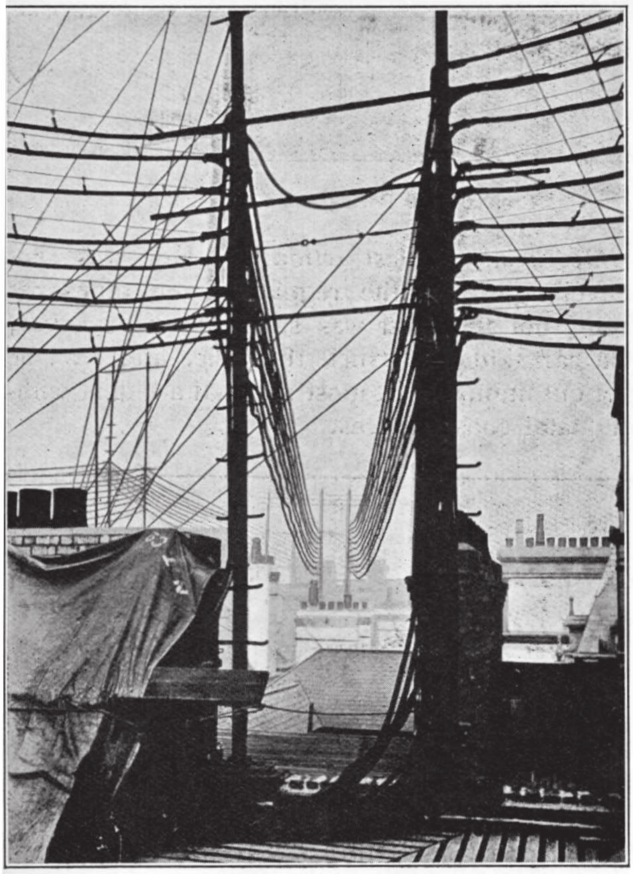
A D.P. (*not in the N.E. Dist.*).—This is the sort of structure one finds at his bed-head after a heavy supper . . . . a thing to be avoided!



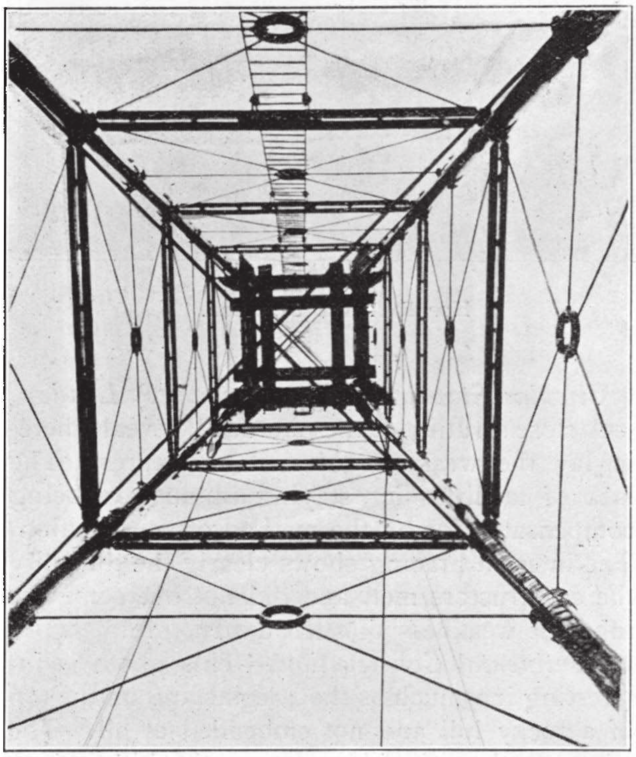
London Overhead Construction—of an earlier date.



Derrick at Derby.



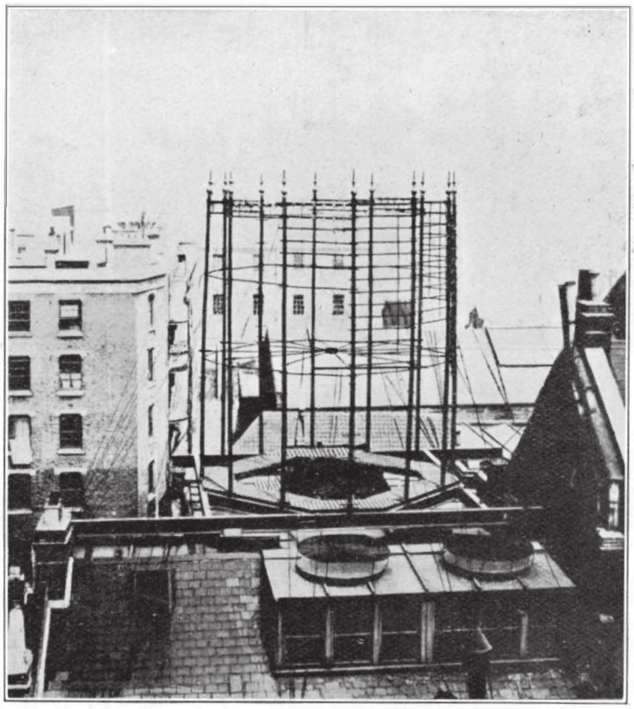
Another Example of Overhead Construction in London.



Derby Derrick from Below.

London Overhead.—These slides are self-explanatory of the difficulty of telephoning London by means of overhead wires and form sufficient evidence of the necessity for underground in the Metropolis and fully supports the wisdom of the Department's present policy.

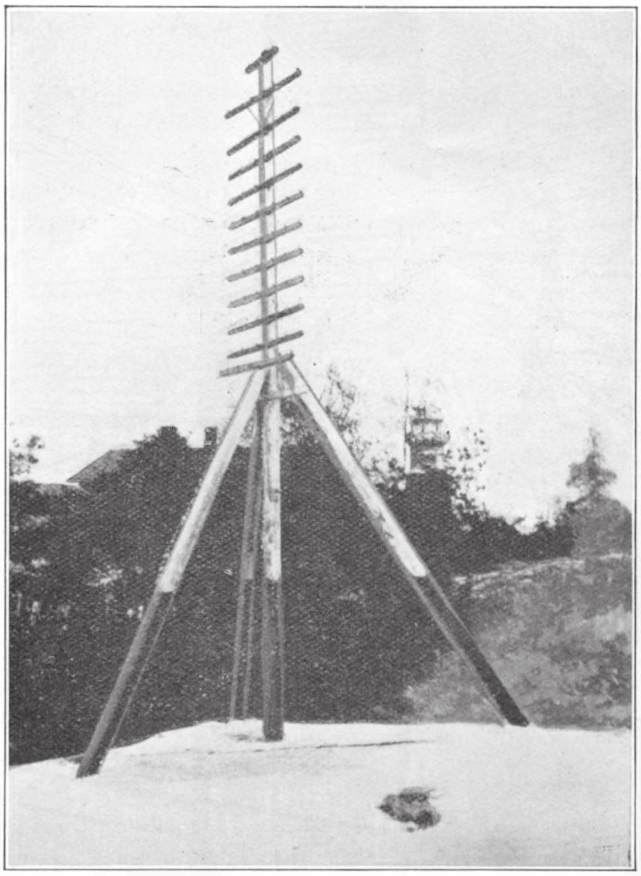
Derrick at Derby.—These photos show a very unusual structure, there being only other 2 such structures in the British Isles. This structure is indicative of the change which has taken place in the minds of telephone engineers, inasmuch as in those days the expense was often out of all relation to the service provided.



Hop Exchange Standard.

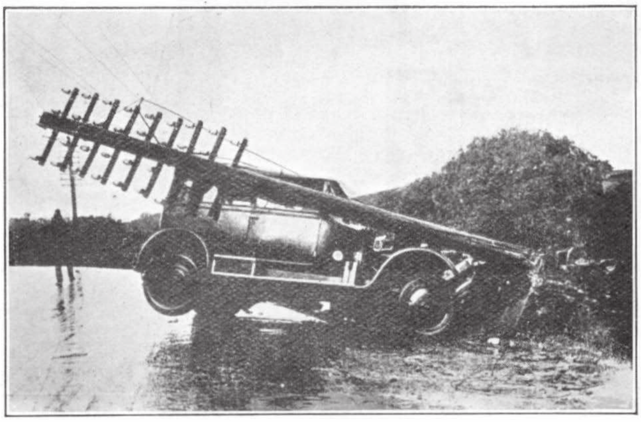
Circular Standard (Hop Exchange) London.—A close scrutiny of the photo will reveal wherein lay the weakness of such structures. The lack of facilities for staying in no way being compensated for by the method of construction. The internal bracing shows clearly the difficulty the constructors met, and did not overcome the inherent weakness of such a structure.

Continental Construction.—This photo is interesting inasmuch as the 4 legs stand on the top of a rocky hill and not embedded at all. The wires on the one side come up the hill and on the other side go down, thus there is compression and the arrangement is indicative of the ingenuity of our Continental friends.



Continental Pole (under pressure).

Overhead "Destruction."—He was not travelling above the regulation ten miles per hour, but the road was slippery; he swerved, the car skidded, struck the pole, and . . . he got out unhurt! A most unusual accident without fatal consequences.



Overhead Destruction!

When it is stated that about 130 slides were thrown on the screen, all of equal interest to those just referred to, it will be appreciated that Mr. Shea gave the local members a most interesting evening. Following the slides, another film was shown, " Beyond the Range of Vision," kindly loaned by Mr. T. Roles, the Bradford City Electrical Engineer, and described the operations of the American Telephone and Telegraph Company (Bell System), proving a very interesting comparison to the previous film and slides.

Naturally, an animated discussion followed and the meeting proved to be one of the most successful ever held in the N.E. District.

NORTH WALES CENTRE.

The fourth meeting of the 1926-27 Session was held at Shrewsbury on 12th January, 1927, when Mr. H. B. Somerville, B.E., of the Engineer-in-Chief's Office, read a paper entitled " The Inspection of Amateur Wireless Stations " to an audience of over 100. At the beginning Mr. Somerville referred to the different kinds of licences issued by the Postmaster-General, and to the conditions usually attached to these, and then went on to describe the kinds of transmitters usually met with at amateur Stations. Slides were projected showing the various circuits usually adopted by amateurs, and the lecturer enumerated the most important points to be observed by officers inspecting such stations, and gave many valuable hints arising from his experience in this branch of the Department's activities. Finally Mr. Somerville illustrated and described the design and use of the D.F. wagon recently placed in commission for tracking down oscillators, and referred also to the portable testing apparatus now being designed for the use of officers engaged on inspections. A prolonged discussion followed, and after Mr. Somerville had replied fully to the numerous enquiries which were raised, the meeting terminated with a hearty vote of thanks.

The fifth meeting of the Session was held at Shrewsbury on 23rd February, 1927, when a paper by Mr. K. Kitchen, of the Engineer-in-Chief's Office, entitled " Local Line Plant Economics," was read by Mr. W. B. Crompton, in Mr. Kitchen's unavoidable absence. The attendance was somewhat below the average for this District owing to the prevalence of influenza and gales. The paper which was copiously illustrated by lantern slides has already been described in the January issue, and the subject was very exhaustively covered. The dicussion which ensued revealed many diverse points of view upon some of the details of practice advocated by the lecturer, and only the proximity of " train times " brought it to a close, in time to enable Mr. Crompton to reply to the numerous points and enquiries which had been put forward.

J.G.K.D.

NORTH WESTERN CENTRE.

A meeting of the Centre was held in the Lecture Hall of the Preston Scientific Society on the 11th January, 1927, when a paper entitled " A Comprehensive View of Automatic Telephony " was read by Mr. W. Beattie, A.M.I.E.E. The object of the paper was to present an exposition of the system on popular lines, avoiding as far as possible any involved technical details.

Mr. Beattie opened his paper with a comparison of Manual and Automatic switching methods and proceeded to deal with the questions of the " holding-time " factor and the grading of traffic. A full description of automatic switching apparatus was then given and the switching of a through call on a provincial 4 digit exchange explained. This was followed by a description of " director " working and an explanation of the means employed in the switching of a call between two exchanges in a " director " area. The paper was illustrated by a working demonstration set and electric arc lantern.

A visit of inspection to the Southport new Automatic Exchange was paid on the 25th January, 1927.

The proceedings opened with a lucid review of the general principles of automatic switching by Mr. S. Upton, A.M.I.E.E. (Executive Engineer) and a working demonstration set was available for purposes of illustration. The members then divided into groups and inspected the Switch, Manual, and Accumulator Rooms, Power Plant, etc., the various details being explained by Messrs. Upton, Beattie, Carr, Tough and Thompson. The visit proved most illuminating and the thanks of the Centre are due to Mr. Upton and his assistants for their co-operation and unsparing efforts which so largely contributed to the success of the function.

On the 14th February, a paper entitled " More about Amateur Wireless Stations " was read by Mr. H. Horrocks. The lecture was in continuation of the one given by the author during the 1925-26 Session. The paper dealt mainly with the question of Oscillation, its causes, detection and remedies, and a description was also given of the new Post Office motor van designed for the purpose of localising " howlers." Receiving and Transmitting Sets were also touched upon and the paper was illustrated by specially prepared diagrams. D.B.

BOOK REVIEWS.

" Radiotechnique Generale." By C. Gutton. (Paris J. B. Bailliere et Fils.) Pp. 572.

This volume contains a comprehensive survey of the fundamental principles of radio communication. The book forms one of a series of works forming an Encyclopædia of Industrial Electricity and edited by Professor M. A. Blondel.

The work consists of eighteen chapters and contains over three hundred diagrams and illustrations. Even in a volume of this size it is only possible to touch the fringe of many of the problems of radio telegraphy; the author has wisely kept to fundamentals and avoided lengthy excursions into the more specialized ramifications of the subject.

The first and second chapters deal with production of high frequency oscillations by spark discharges; chapter three deals with the production of oscillations by means of the electric arc, and chapter four with high frequency alternators. Chapters five and six are devoted to three electrode valves and their use in the production of oscillations. Chapters follow on coupled circuits, propagation along wires, propagation of electromagnetic waves and high frequency resistance of conductors. The actual equipment of transmitting installations is next described, space being given to spark, arc, alternator and valve sets and under the latter some mention is made of short wave transmitters. These first eleven chapters comprise about three hundred pages.

The subject of reception is dealt with under the headings of detection and amplification and this is followed by a long chapter on receiving sets.

Succeeding chapters are devoted to Direction Finding, Radiotelephony and high frequency measurements.

The work is well balanced and the author gives mathematical proof as far as possible for the formulæ used. Chapters which appear to be particularly good are those on the production of oscillations by three electrode valves, on coupled circuits, and on amplification and receiving apparatus. The first-mentioned chapter contains a mathematical analysis of the conditions governing the production of oscillations, which is probably fuller than that presented in any other text book. On the subject of reception the author states that the grid leak method of detection is more sensitive than anode rectification. Experience seems to indicate that this is not necessarily the case, since the additional damping introduced by the grid leak method can nullify its advantage when the detector is preceded by circuits having very low decrements.

Articles on high frequency measurements would be much more valuable if the percentage error likely to be encountered were stated. In the present work such figures are given in only a few instances. The chapter on this subject would have been improved by the substitution of more modern methods in place of those involving the use of buzzer excited wavemeters.

The work is a valuable contribution to literature on Radio communication, and can be confidently recommended. A. J. Gill.

" Dictionary of Wireless Technical Terms." By S. O. Pearson. London, *The Wireless World*, Iliffe & Sons, Ltd. 254 pp. 2/- net.

This is a useful little volume, of handy size for the pocket, containing simple definitions of a large proportion of the terms used in radio telegraphy.

There are one or two definitions which should receive amendment. The definition of "tone wheel" is incorrect. The tone wheel is a rectifying commutator for C.W. reception and was first used in connection with the Goldschmidt system. An interrupter for converting C.W. into I.C.W. is usually called a "chopper."

The definition of the Push-Pull Amplification implies that this is only used in the final stage of a low frequency amplifier. This is not strictly correct as it has important applications for ultra high frequency amplification.

It is also hardly correct to say that the three electrode valve has almost entirely superseded the two electrode valve. This is true only so far as receiving rectifiers are concerned, but it is not the case as regards transmitting rectifiers.

These points detract little from the value of the work, which is full of useful information for those who require something a little more explanatory and discoursive than a list of standard definitions.

A. J. Gill.

"A First Course in Wireless." By R. W. Hutchinson, M.Sc., A.M.I.E.E. London, University Tutorial Press, Ltd. 262 pp., 207 illust. 3/6 net.

This book is stated by the author to be intended for beginners, for wireless amateurs and experimenters and for students in Secondary and Technical Schools and evening Technical Classes.

The first six chapters, comprising a hundred pages, are devoted to elementary electricity and magnetism.

The remaining portion of the book is devoted to a brief elementary survey of radio telegraphy and telephony, chiefly from the point of view of the broadcast listener, although other applications are occasionally mentioned.

There are a number of illustrations of broadcasting sets and components by different makers and a large number of circuit diagrams of broadcast receiving sets, which appear to have been culled from the popular press. At the end of the book formulæ are given for the calculation of inductance and capacity, but the reader is not told how to use these values to determine the wavelength or other properties of a circuit.

There are numerous errors and loose statements, as for example on page 161 the performance of frame aerials with radial and axial windings are compared to the disadvantage of the former type. Actually the directional properties of both types are identical.

On Fig. 203 a telephony modulation circuit is shown and the student is recommened to "carefully think out the action of this circuit." The student is set a difficult task, as an essential item, the modulation choke, has been omitted. The writer also appears to be unable to distinguish between genuine advances in engineering practice and the fads and fashions of a few weeks duration, as for example when we are informed that in the best wireless receivers the square low condenser has replaced the ordinary type.

The title of the work and the claims in the preface suggest that it would be suitable as a class book, whereas in fact it is quite unsuited for the purpose. The subject matter is neither suitable in type nor sufficiently quantitative in character for the book to have any value for educational purposes.

A. J. Gill.

"The Practical Telephone Handbook." By Joseph Poole, A.M.I.E.E., Wh.Sc. Sir Isaac Pitman & Sons. 18/- net.

This, the seventh edition of this well-known handbook, is a great advance on previous editions. The book has now 870 pages and contains 687 figures, the whole excellently printed and the diagrams well drawn and clear. The increase in size since the sixth edition is 140 pages, but this does not represent the whole of the new matter, as a considerable amount of obsolete and less important material has been omitted to make way for the augmented and rewritten chapters on Automatic Telephony Transmission, Telephone Repeaters and Wireless Telephony. The chapter on Automatic Telephony is now 112 pages in length, but there are numerous points not covered. We think that instead of giving circuits of each of several systems it would be better to give one system in greater detail, but it is realised that there will continue to be difficulties from an author's standpoint until the B.P.O. standardises the circuits. At the same time it must be agreed that the 112 pages could be put to much better use if such standardisation existed. It is noticed that the author has not yet adopted the "detached contact" system of diagrams which is so helpful and now so widely adopted in this country for study purposes.

B.O.A.

"Junior Technical Electricity." By Robert W. Hutchinson, M.Sc., A.M.I.E.E. University Tutorial Press, Ltd. Price 4/6.

The appearance within a year of a second edition of this excellent little work shows that it has been well received by teachers of First Year Electrical Engineering Courses. The new edition contains a little new matter in connection with "wireless," but otherwise is substantially a reprint. It is a book that can be thoroughly recommended.

B.O.A.

"Intermediate Text-book of Magnetism and Electricity." By Robert W. Hutchinson, M.Sc., A.M.I.E.E. University Tutorial Press, Ltd. Price 9/6.

We have also received a copy of the second edition of Mr. Hutchinson's Intermediate Text-book. The chief changes are in respect of Chapter XXI. on Electric Oscillations, etc. The book covers the Intermediate Examinations of the Universities, and is also suitable for the use of candidates for the various examinations of Civil Service, where Electricity and Magnetism is offered as a subject. The book well upholds the high standard of the series in which it appears.

B.O.A.

"Makers of Science—Electricity and Magnetism." By D. M. Turner, M.A., B.Sc. (Lond.). Oxford University Press. Price 7/6.

This volume is one of a series designed to introduce to the young student the philosophical outlook of men of science eminent in their particular branches. It deals with the work of the pioneers in electrical science from the earliest records, and is not merely biographical; it describes in an admirable way the steps by which the Science of Electricity and Magnetism has progressed, and the method by which the great experimenters worked. The book contains very complete references to the critical literature of the subject and this forms a valuable aid to a student who wishes to follow up any particular line of development in greater detail.

B.O.A.

"Alternating Current Rectification." By L. B. W. Jolley, M.A. (Cantab.), M.I.E.E., Assoc. Amer. I.E.E. Chapman & Hall, Ltd. Price 30/- net.

The first edition of this work was published in 1924, but recent improvements in the design and manufacture of most of the important types of rectifier have necessitated a somewhat early revision.

The book covers an extensive field and deals not only with apparatus depending upon the basic principles of electrical engineering, but also with rectifiers where operation is due to chemical and physical phenomena.

Following an introduction on the subject of rectification in general, the first chapter deals in a comprehensive manner with the subject of Harmonic Analysis of Wave Form. This matter is clearly explained and an indication is given of the correct type of instrument to use in given circumstances.

The second part of the book is devoted to a consideration of mechanical rectifiers, an especially interesting chapter being given on synchronous commutator rectifiers. A very clear exposition is given of the "Transvertor," which at present appears to be the only machine capable of converting a large amount of power to very high D.C. voltages.

The mercury arc rectifier, which owing to its high efficiency, simplicity of operation and other advantages has gone far to displace motor and rotary converters on the Continent and in America and which will no doubt become more popular in the British Isles with the development of A.C. generating stations, receives adequate treatment, about one quarter of the book being devoted to its consideration.

The operation of the vacuum tube rectifier is now well understood in its relation to radio work, but it is not fully appreciated that the valve may have a field of application in power electrical engineering. The author describes an installation of water-cooled valves capable of giving an output of 5 amps. at 30,000 volts and indicates that further developments in this direction are likely to take place.

The latter portion of the book deals chiefly with apparatus which is becoming of practical importance due to the increasing popularity of wireless broadcast reception.

The foregoing is not by any means a comprehensive statement of all the book contains, but is an outline of the salient points likely to be of great interest. Its value is considerably enhanced by the extensive bibliography at the end of each section. This feature might with advantage be followed by other writers of scientific works.

The volume is well compiled and is excellently illustrated by photographs and diagrams. Comparatively speaking it is free from errors, although on figure 252*a* the scale has been omitted from a graph of an efficiency curve and on page 395 there is a reference to sulphuric acid with a specific gravity of 1.00. An error also appears in the index where page 251 should read 351.

H.C.J.

" Wireless Loudspeakers." Iliffe and Sons. 139 pages. By N. W. Mclachlan. 2/6 net.

This little book has been written with a view of collecting together information covering the salient points concerned with the design and use of loudspeakers of various types. A considerable section deals with the use of suitable circuits for operating the loudspeaker. If the information and advice given were taken to heart and acted upon there would be heard less of the raucous and unpleasant reproduction so prevalent at present, even with exhibition outfits where one would at least expect better quality.

The treatment is generally of a popular character, but a great deal of useful information is included.

The book opens with some general comments upon acoustics and discusses the requirements to be met for good reproduction and the causes of poor reproduction. The effects of diaphragm resonance, size and shape of diaphragms, use of baffles, etc., are lucidly dealt with and the author then passes to the description and discussion of various methods of drive.

One or two horn type loudspeakers are illustrated, but the author is evidently very much in favour of some form of Cone type of loudspeaker. Several of these are described, including a powerful model designed by the author.

In the section dealing with suitable amplifiers the author refers to the faults usually found and their remedy and emphasises the necessity for careful design in the amplifier.

The paper, printing and diagrams are all very good and the book can be confidently recommended.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Jenkins, I. H.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	29-12-26
Harris, Major E. C.	Assistant Engineer, S. Mid. District.	Executive Engineer, S. Mid. District.	17-12-26
Morgan, J. A.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	5-1-27
Lock, F.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	5-1-27
Stretch, W.	Probationary Assistant Engineer.	Assistant Engineer.	1-2-27
Owen, J. McA.	,,	,,	,,
Jones, F.	,,	,,	,,
Wyllie, T. O. K.	,,	,,	,,
Hodge, G. W.	,,	,,	,,
Chapman, F. B.	,,	,,	,,
Procter, W. S.	,,	,,	,,
Morrish, H. E.	,,	,,	,,
Houchin, R. E. H.	Inspector, S. Mid. District.	Chief Inspector, S. Mid. District.	7-6-26
Humphries, P. W.	Inspector, S. Western District.	Chief Inspector, S. Western District.	5-7-25
Prior, G.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	24-11-26
Dunk, W. G.	Inspector, E.in-C.O.	Chief Inspector, E.-in-C.O.	27-4-26
Woodward, G. W.	Inspector (Wireless Overseer) Devizes Radio Station.	Chief Inspector, Devizes Radio Station.	1-10-26
Goddard, J. R.	Inspector (Wireless Overseer) St. Albans Radio Station.	Chief Inspector, St. Albans Radio Station.	1-10-26
Lewis, A. F.	Inspector, London District.	Chief Inspector, London District.	24-11-26
Sullivan, W. A.	Inspector, London District.	Chief Inspector, London District.	24-1-27
Baillies, D. C.	Inspector, Scot. West District.	Chief Inspector, Scot. West District.	25-10-26
Elwell, R. A. J.	Telegraphist, C.T.O.	Repeater Officer, Class II., Eastern District.	10-7-26
Richards, C. E.	S.W. Class I., E.-in-C.'s Office.	Inspector, E.-in-C.'s Office.	2-11-26
Mortimore, W. H.	Repeater Officer, Class II., Eastern District.	Repeater Officer, Class I., Northern District.	21-9-26
Honeyman, J. B.	S.C. & T., Edinburgh.	Repeater Officer, Class II., Scotland East.	26-9-26
Gaunt, J. L.	S.W. Class I., Oxford Radio.	Inspector, Oxford Radio.	24-10-26
Godfrey, G. M.	S.W. Class I., S. Mid. District.	Inspector, S. Mid. District.	6-3-26
Peck, H. J.	S.W. Class I., S. Mid. District.	Inspector, S. Mid. District.	1-4-26
Leake, R. J.	S. W. Class I., N. Ireland.	Inspector, N. Ireland.	1-11-26

APPOINTMENTS.

Name.	Grade.	District.	Date.
Sloss, J.	Fourth Engineer.	H.M.T.S. Alert.	26-1-27
Doust, J. F.	Probationary Assistant Engineer.	E.-in-C.O.	5-1-27
Dunford, L. G.	,,	,,	,,
Sephton, N. F.	,,	,,	,,
Bell, H. S.	,,	,,	,,
Bentlett, W. J.	,,	,,	,,
Smith, H. S.	,,	,,	,,
Halsey, R. J.	,,	,,	29-1-27
Ramsay, M. W.	,,	Testing Branch.	17-1-27
Millar, H. T. W.	,,	,,	31-1-27
Salter, L. F.	,,	,,	19-1-27
Blake, D. E.	,,	,,	18-1-27
Phillips, R. S.	,,	E.-in-C.O.	19-1-27
Bourdeaux, N.	Probationary Inspector	,,	—
Arman, L. T.	,,	,,	1-3-27
Simpson, C.	,,	S. Lancs.	—
Young, J. E.	,,	Testing Branch (Birmingham).	1-3-27
Dore, L. J.	,,	E.-in-C.O.	21-2-27
Devereux, R. C.	,,	,,	16-2-27
Shrubsall, F. W.	,,	,,	—
Henderson, V. R.	,,	London.	17-2-27
Barrett, H,	,,	E.-in-C.O.	22-2-27
Barry C.	,,	S. Lancs.	—
Blackburn, E.	,,	North East.	—
Millen, G. J.	,,	E.-in-C.O.	21-2-27
Perryman, C. F.	,,	,,	21-2-27
Hibbs, A.	,,	Testing Branch (London).	21-2-27
Salt, R. S.	,,	,, (Birmingham).	18-2-27
Seymour, E. H.	,,	,, (London).	28-2-27

APPOINTMENTS—continued.

Name.	Grade.	Promoted to	Date.
Hayes, H. C. S.	Probationary Inspector.	S. Wales.	—
Roberts, J. H.	,,	Testing Branch (London).	23-2-27
Neale, J.	,,	E.-in-C.O.	—
Knox, A. H. C.	,,	Testing Branch (Birmingham).	16-2-27
Lowne, W. R. J....	,,	,, (London).	15-2-27
Coleman, W. I. A.	,,	,, (Birmingham).	23-2-27

RETIREMENTS.

Name.	Grade.	District.	Date.
Ramsay, M.	Staff Engineer.	E.-in-C.O.	22-3-27
Macpherson, H.	Executive Engineer	S. Midland.	11-2-27
Rolfe, W. J.	,,	N. Western.	31-3-27
Bell, A. J.	Assistant Engineer.	E.-in-C.O.	31-3-27
Savage, A....	Chief Inspector.	S. Lancs.	31-12-26
Hayward, J.	,,	,,	1-1-27
Hall, C. W.	Inspector.	Northern.	4-2-27
Johnston, R.	,,	London.	31-1-27
Bell, F.	,,	Northern.	12-2-27
Bagley, W.	,,	N. Wales.	31-12-26
Thomas, W.	,,	S. Western.	11-12-26
Stow, J. S.	,,	London.	14-2-27

DEATHS.

Name.	Grade.	District.	Date.
McInnes, H. A.	Assistant Staff Engineer.	E.-in-C.O.	11-1-27
Watson, D. W.	Executive Engineer	Scot. West.	15-2-27
Gill, R.	Assistant Engineer.	N. Eastern.	13-1-27
Bell, H. S....	Probationary Assistant Engineer.	E.-in-C.O.	20-1-27
Smith, F.	Chief Inspector.	London.	15-1-27
Judd, H. I.	Inspector.	,,	11-1-27

TRANSFERS.

Name.	Transferred.		Grade.	Date.
	From.	To.		
Hansard, A.	E.-in-C.O.	S.Mid. District.	Assistant Engineer.	1-1-27
Parker, T.	S. Eastern District.	N.E. District.	,,	29-12-26
Whittle, J. G.	London District.	S.Lancs. District.	Chief Inspector.	17-2-27
Winter, J.	S. Lancs. District.	N.Ireland District.	,,	7-11-26

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	District.	Date.
Owen, W. G.	Clerical Officer, London.	Executive Officer, E.-in-C.O.	9-1-27
Dauncey, A. J. W.	Clerical Officer, N. Wales District.	,,	9-1-27
Copeland, P. L.	Clerical Officer, E.-in-C.O.	,,	12-8-26
Price, Capt. C. E.	,,	,,	,,
Cowley, P. J.	,,	,,	,,
Bolt, F. R....	,,	,,	,,
Eames, E.	,,	,,	4-11-26
Dunster, H. L.	,,	,,	11-12-26
Smalley, A. T.	,,	Acting Executive Officer, E.-in-C.O.	18-10-26
Davidson, R. S.	,,	,,	4-11-26
Ost, H. J.	,,	,,	11-12-26
Blackman, Miss I. C.	Writing Assistant, E.-in-C.O.	Female Clerical Officer, E.-in-C.O.	2-2-27

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THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ESSAY COMPETITION, 1926-27.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows:—

1. J. S. Dennis, Repeater Station, Fenny Stratford.
   "The Modern Conception of the Structure of Matter."
2. J. Bingham, Repeater Station, Newcastle.
   "The Fundamental Principles and Characteristics of the Western Electric Telephone Repeaters."
3. F. V. Padgham, Repeater Station, Guildford.
   "Transmission Testing Sets."
4. R. L. Ryan, Radio Station, Devizes.
   "The Arc Transmitter."
5. E. H. Jeynes, Repeater Station, Gloucester.
   "Photo-Telegraphy and Television."

The Council has decided to award Certificates of Merit to the following five competitors who were next in order of merit:—

6. S. E. Price, Testing Branch, Birmingham.
   "The Secondary Cell."
7. N. V. Knight, Automatic Exchange, Oxford.
   "Automatic Exchanges—Non-Director Areas."
8. J. H. Sundewall, Repeater Station, Fenny Stratford.
   "Management of Oil Engines in Telephone Repeater Stations."
9. W. F. Goodman, Sectional Engineer's Office, Exeter.
   "Local Line Records."
10. W. G. Johnson, Birmingham Section.
   "The Change Over of the M.D.F. at Birmingham H.P.O."

The number of entries was 91, and the Judges reported that there was a further improvement in the average quality of the essays submitted.

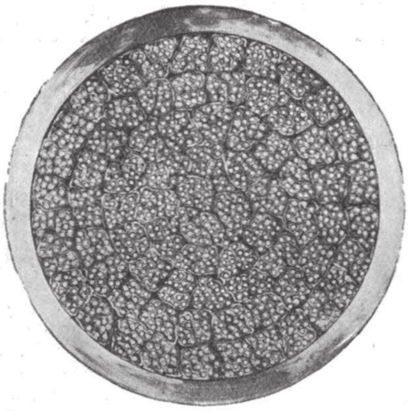
R. V. Hansford,
Secretary.

March, 1927.

CENTRAL LIBRARY.

The following books have been added to the Central Library. Applications for the loan of same should be addressed to the Librarian, Institution of P.O. Electrical Engineers, Alder House, E.C.1.

List 1. *No.*	***Title.***	*Author.*
827	Portland Cement, Everyday Uses of	The Cement Marketing Coy.
828	Alternate Current Rectification...	L. B. W. Jolley.
829	High Vacuum	Kaye.
830	Wireless Pictures	Baker.
831	Director System of Automatic Telephony	W. E. Hudson.
832	Radio and High Frequency Currents	E. T. Larner.
833	Elements of Radio-Communication	O. F. Brown.
834	Electrical Condensers	P. R. Coursey.
835	Theory of Vibrating Systems and Sound	J. B. Crandall.



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Peel-Conner Telephone Works, Ltd....	xv
Pirelli-General Cable Works, Ltd. ...	xvi
Pitman & Sons, Ltd.	xi
Rentell & Co., Ltd.	viii
Standard Telephones and Cables, Ltd.	x
Sterling Telephone and Electric Co., Ltd.	xiv
Siemens Bros. & Co., Ltd. ...	vi and vii
Taylor Tunnicliff & Co., Ltd. ...	viii
Telephony Publishing Corp.	xii
The Electrical Review, Ltd. ...	viii
The Relay Automatic Telephone Co., Ltd.	xiii
Zeva Elektricitats AKT. GES. ...	xii

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COTTON-COVERED AND BRAIDED WIRES.
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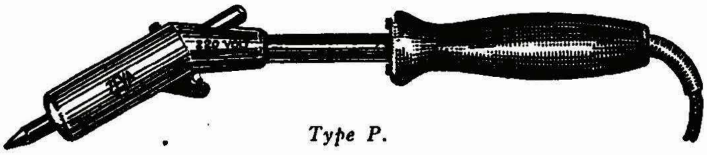

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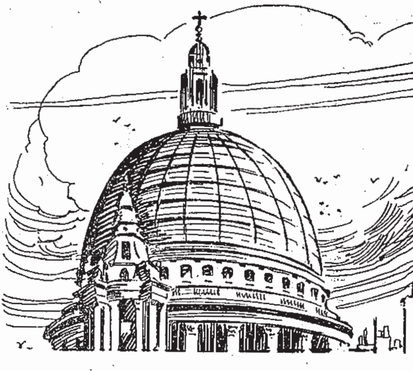

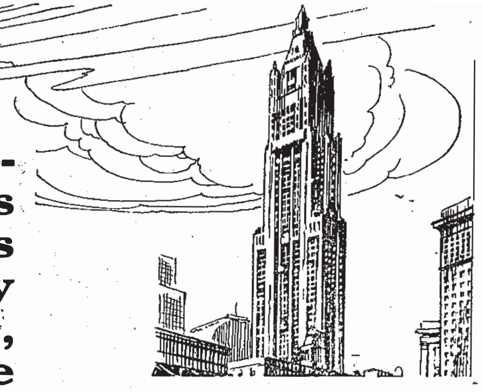

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One of the first telephone calls across the Atlantic was made in the "Daily Express" Office, London, on the Relay Automatic Branch Exchange.

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TELEPHONE service has been improved in proportion as relays have been more largely employed, and this perhaps is the most convincing testimony that can be offered to the reliability and high reputation enjoyed by relays.

The Relay Automatic Telephone System is composed entirely of specially designed relays—it is all electrical and employs no electro-mechanical switches or other moving parts. Relay installations require no oiling or cleaning; they are practically silent and motionless and are not affected by varying climatic conditions.

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Over 90 per cent. of the Private Automatic Branch Exchanges rented to subscribers by the British Post Office have been supplied and installed by the Relay Company.

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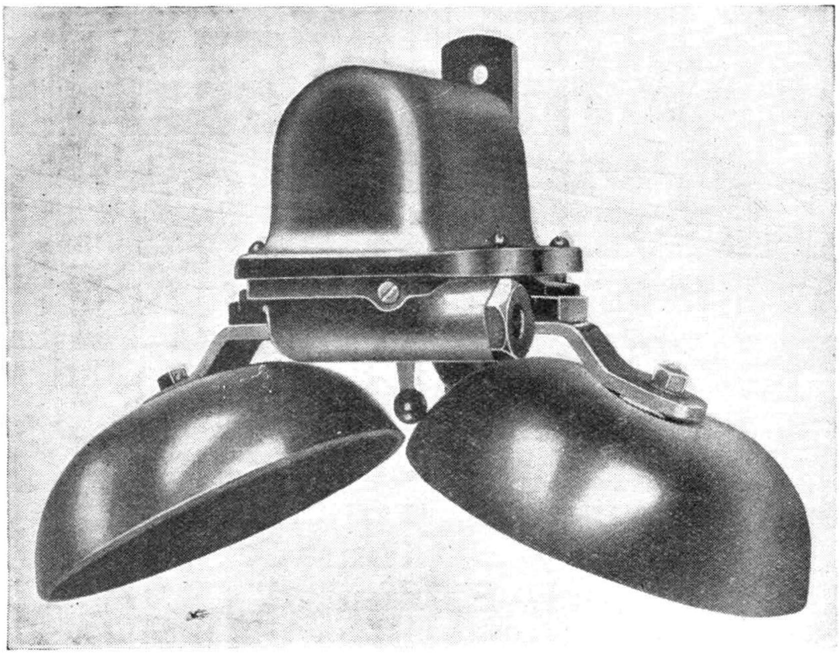

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LONDON
REGD TRADE MARK

Weatherproof LOUD RINGING BELLS.

THE accompanying illustration is of a weather-proof Bell of unusual design and high efficiency, for use on alternating current circuits of any frequency up to 75 periods. The operating movement is extremely powerful, having a resistance of 1000 ohms for standard use.

It can be used on pressures up to 220 volts for continuous working. This voltage may be increased by 50% to 100% for intermittent working.

The signal given is of a very distinctive character, easily distinguished from other signals, and can be heard over a considerable area.

As a Telephone Extension Bell for use in conjunction with standard pattern telephones it is superior to those previously designed. It eliminates relays and local bell circuits so often used for want of an efficient loud extension bell.

Brief Specification:

Robust cast metal case, bright black stoved enamel finish.

Hammer protrudes through aperture underneath: protected by gongs. Access to terminals and working parts by removing cover, held with four screws. Cover clamps down on to suitable packing in base: watertight joint. A No. 1 watertight cable gland of British Engineering Standards Association specification is fitted at side to take incoming cable. A wrought iron fixing strap is fitted to eliminate the risk of the Casting breaking, due to strain when fixing. Gongs mounted eccentrically to allow of ample adjustment. Earthing terminal is fitted near cable gland.

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Peel-Conner Telephone Works

(*Proprietors*—THE GENERAL ELECTRIC CO., LTD.)

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BURSLEM (2,200).
CHESTERTON (200).
COVENTRY (5,500).
DUNDEE (4,500).
EXETER (3,500).
FOLESHILL (1,000).
HANLEY (2,000).
HARROGATE (5,500).
KEIGHLEY (2,000).
LONGTON (1,100).

NEWCASTLE-UNDER-LYME (1,000).
STOKE-ON-TRENT (1,500).
TOPSHAM (400).
TRENTHAM (500).
MIDDLESBROUGH (3,800).
STOCKTON-ON-TEES (2,200).
LINTHORPE (1,000).
SOUTHBANK (400).
ARCHWAY (5,800).
EDGWARE (2,900).
KENSINGTON (9,900).
RELIANCE (4,400).
} LONDON DIRECTOR SYSTEM.

Australia.

CENTRAL (TANDEM).
BRIGHTON (1,000).
GLENELG (2,000).
HENLEY (1,000).
PROSPECT (3,000).
WOODVILLE (1,000).

India.

CAWNPORE (2,000).
MADRAS (9,000).
RAISINA (NEW DELHI), (3,000).
LOTHIAN ROAD (OLD DELHI), (3,000).
BENGAL COAL FIELDS (SIX EXCHANGES) } (2,260).

New Zealand.

DANNEVIRKE (1,900).
HAWERA (2,000).

Gibraltar.

GIBRALTAR (800).

NOTE—The bracketed figures are the subscribers line capacities of the exchanges.

HEAD OFFICE AND WORKS:
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Telegrams: SPRINGJACK, COVENTRY.

LONDON OFFICE:
Magnet House, Kingsway, W.C.2
Telephone: REGENT 7050.
Telegrams: PEELCONTEL, WESTCENT, LONDON.

THE
Post Office Electrical Engineers' Journal

THE NEW TELEGRAPH REPEATER STATION AT LOWESTOFT (LWV).

E. G. FURNEAUX.

A DESCRIPTION of the old station was given in this Journal, Vol. XVI., Part 4, p. 295.—The space available for the apparatus in that building was not sufficient to enable the best possible working conditions to be obtained, and as the lease was about due for renewal arrangements were made to obtain a better position and with better working conditions. The one disadvantage is that the Anglo-German cables and one Dutch cable have had to be increased in length by the addition of 784 yards of paper-insulated lead-

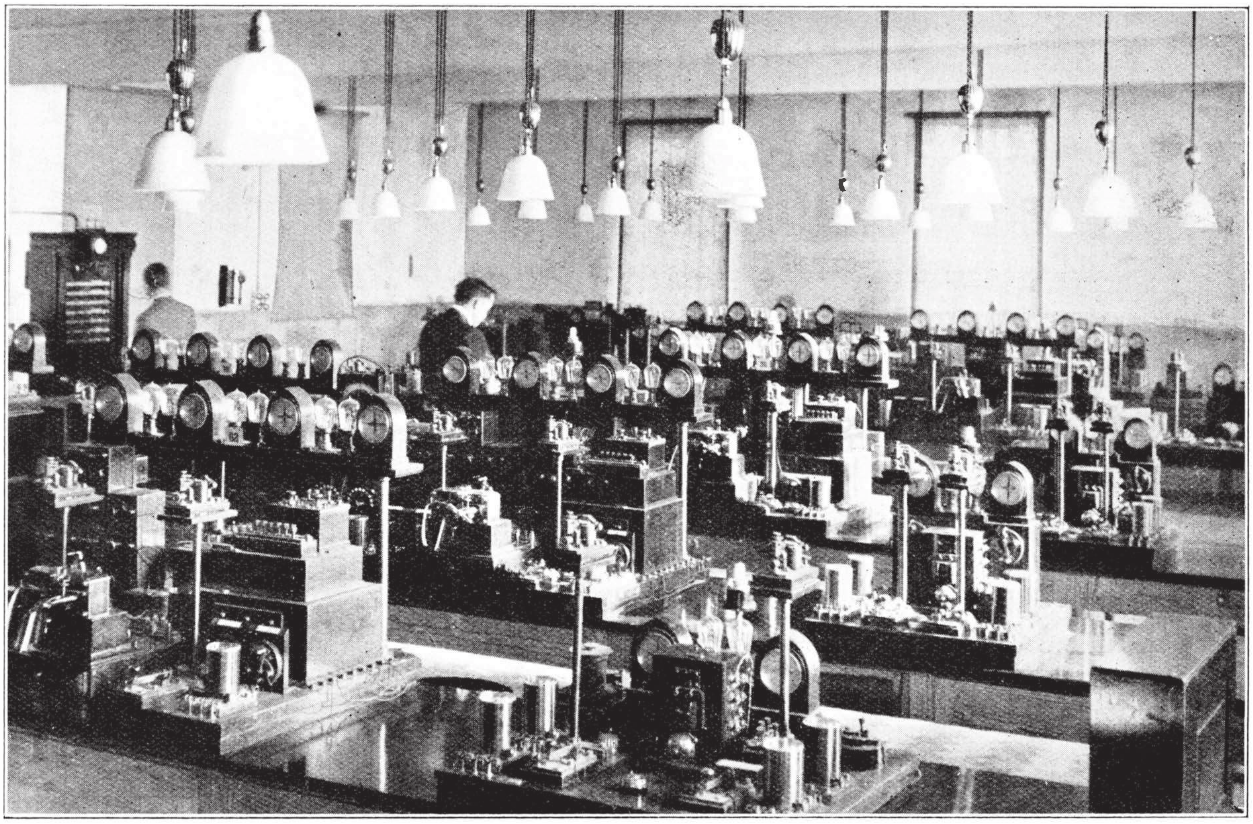


FIG. 2.—PORTION OF INTERIOR OF REPEATER STATION.

covered cable, but the two Dutch cables *via* Benacre have been decreased in length by a similar amount.

Fig. **1** gives a view of the new building which is situated on Battery Green and overlooking a portion of the harbour. It has a very pleasing appearance with its walls of Atlas white cement, purple brick dressings and wide low-pitched roof of small slates.

Fig. **2** shows a portion of the Repeater Room, which occupies most of the first floor and has windows on three sides; the fourth side separates this room from the retiring room and the staircase.

A plan of the first floor is given in Fig. **3** and shows the chief dimensions, positions of the tables and the Repeaters for the various circuits. Repeaters 41 to 48 are used on the German cables, and 33 to 62 on the Dutch lines.

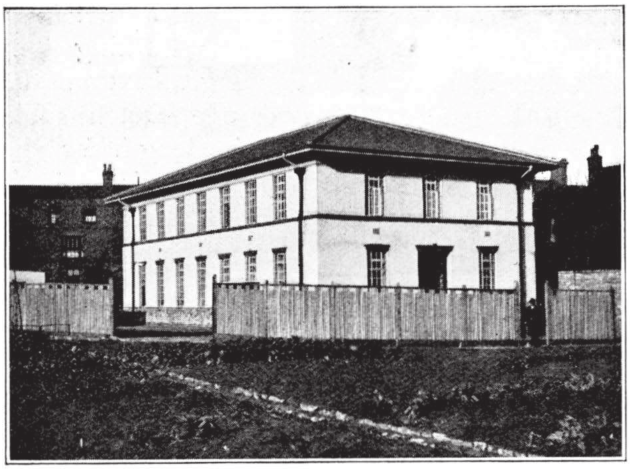


FIG. **1**.—LOWESTOFT TELEGRAPH REPEATER STATION.

There are five repeaters on each table, four being for use on the four wires of a cable and one in reserve.

The systems in use are Baudot Triple and Double Duplex, and Hughes Simplex or Duplex for the public lines, while Wheatstone Duplex and Western Union Double Duplex are used on the two private wire circuits.

The spare repeaters are for Simplex Hughes working in order to avoid changes in the adjustment of relays and duplex balances when the double-current duplex systems are closed down for night and Sunday working and are replaced by single-current Hughes simplex sets. The time required to cross from one Repeater to another is very much less than the time required to re-arrange the adjustments on the double-current duplex boards.

On the submarine cable side the working is by single wire with "Earth," but on the London side the circuits are metallic loops without "Earth," requiring separate batteries for each circuit.

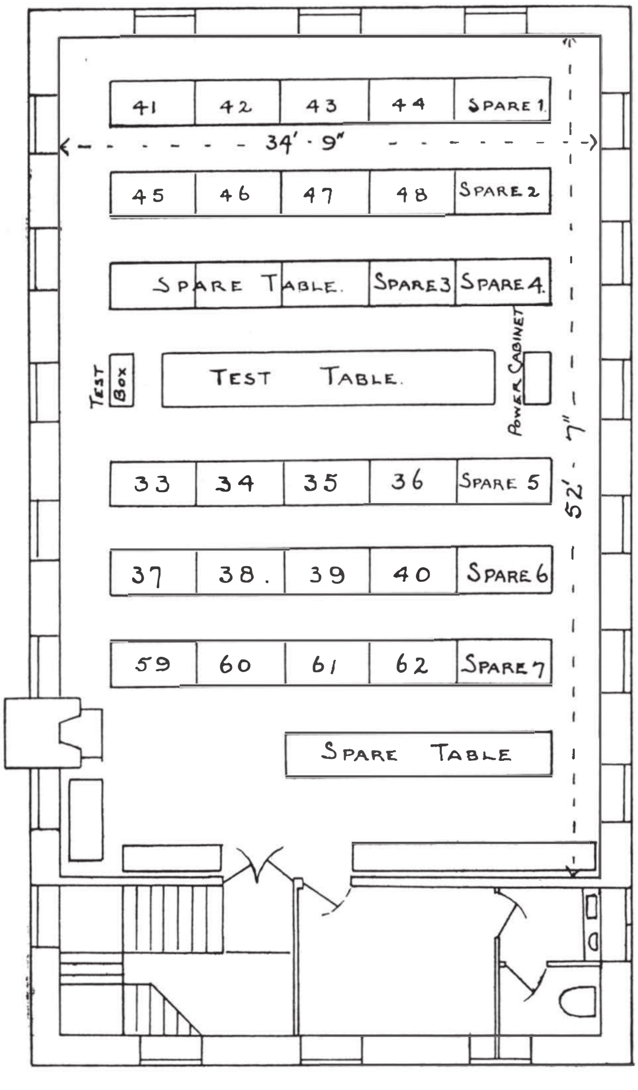


FIG. **3**.—PLAN OF REPEATER ROOM, SHOWING ARRANGEMENT OF INSTRUMENT TABLES.

The extensions of the submarine cables are made by conductors of approximately the same size as those of the submarine conductors.

The change from open aerial wires to underground cable has added materially to the stability of the services, both in regard to the lessened liability to interruption and to the preservation of the duplex balances.

The Ground Floor, Fig. 4, provides an office for the Engineering Inspector, a room for the linemen and stores, a heating chamber, a dynamo room, and space for the batteries.

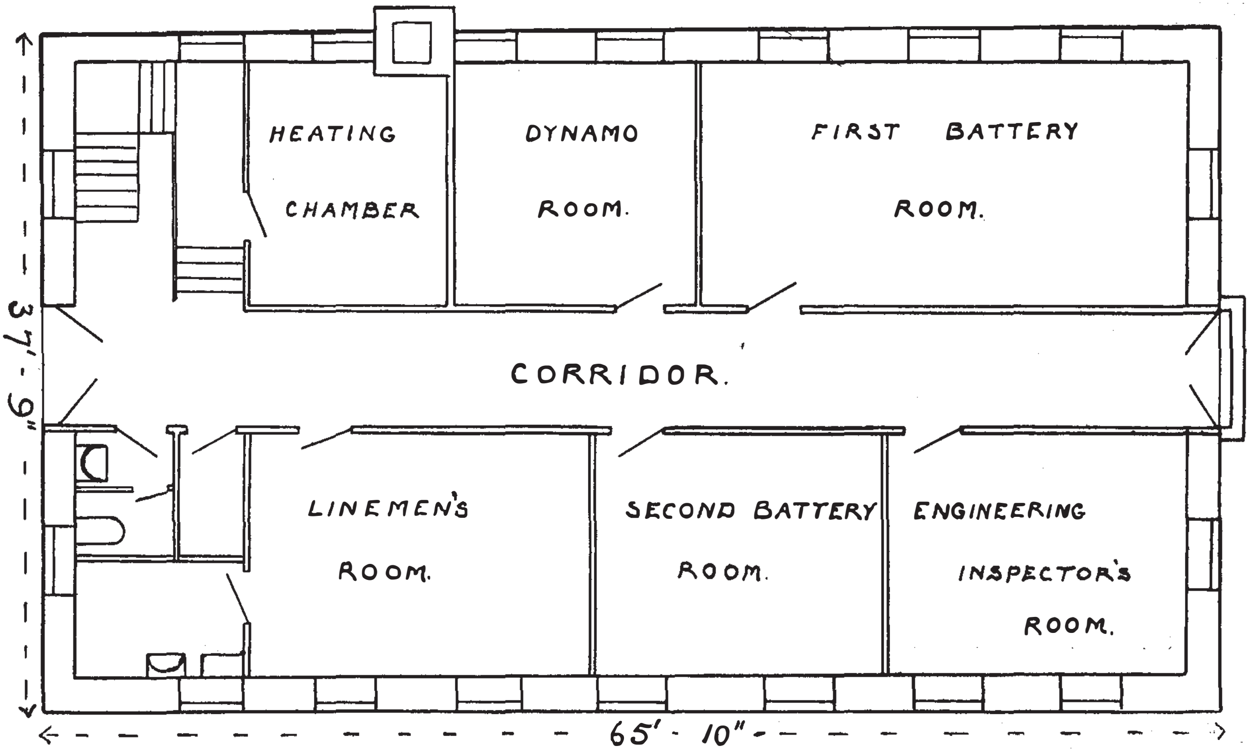


Fig. 4.—Plan of Ground Floor.

DETECTOR No. 4.

Captain H. Yorke Starkey.

THIS instrument has been evolved with a view to meeting the more stringent conditions due to the changes in the nature of telephone plant to be maintained and, at the same time, to provide a robust detector suitable for general maintenance purposes. The apparatus has been designated " Detector No. 4," and takes the form of a combined voltmeter and ammeter of the moving coil type. It may be regarded as a refinement of the familiar Detector No. 2.

In addition to the instrument itself, shunts and resistance coils or multipliers are provided for external connection by means of which the current and voltage ranges may be considerably increased. A contact spike is also provided which, when not in use, is housed in a slot at the back. When required the spike is screwed into a socket at the base of the instrument. The spike facilitates the use of the detector in point-to-point testing such as D.P.'s across bolted connections and voltage of individual cells.

The illustration, Fig. 1, gives a general view of the detector together with the accessory resistances, shunts and spike.

The introduction of the compound switch permits of the necessary external connections being made by provision of only 4 terminals. The switch is of a novel character and is in the form of a commutator and, contrary to the usual practice in switches of this nature, is so arranged that the "clicks" are between the "on" positions. The switch connections are thereby made by rubbing contacts which ensure good connection. A margin of operation is also allowed on either side of the switch point. The switch and terminals are shown in Fig. 2.

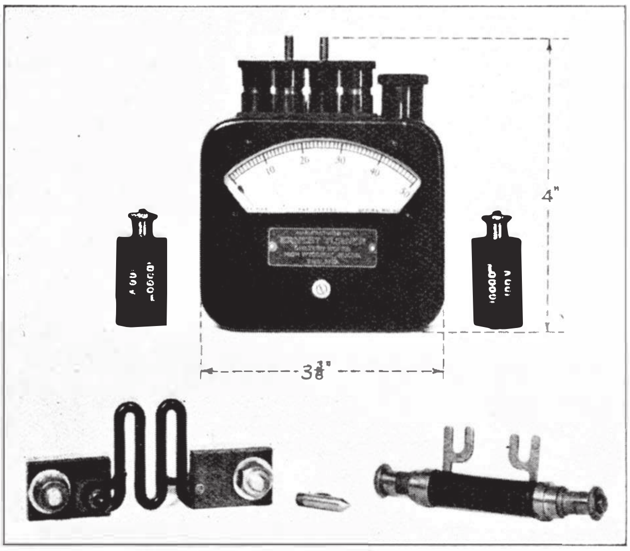


FIG. 1.—GENERAL VIEW OF DETECTOR NO. 4 AND PARTS.

No. 2 terminal is common to all tests and is marked "common positive." Separate terminals are used for current and voltage readings, while the fourth gives connection direct to the moving coil circuit through a fuse.

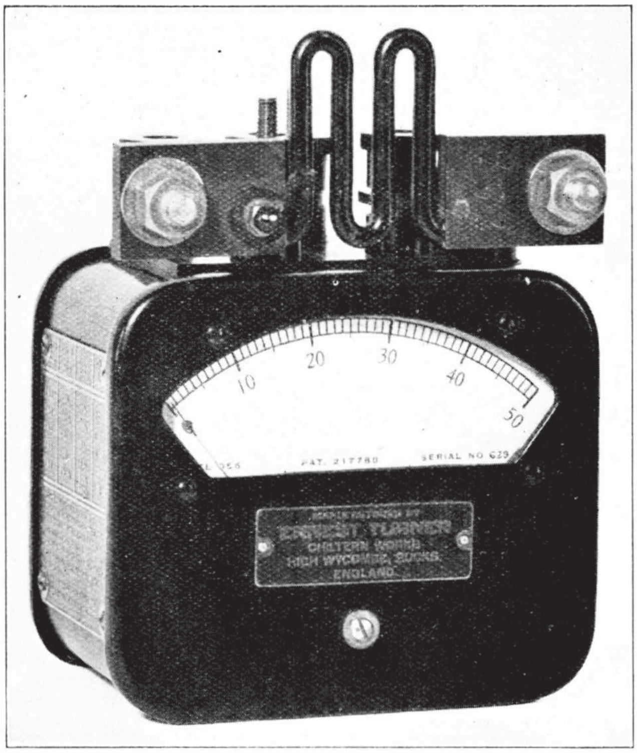


FIG. 3.—DETECTOR WITH 25-AMP SHUNT FITTED.

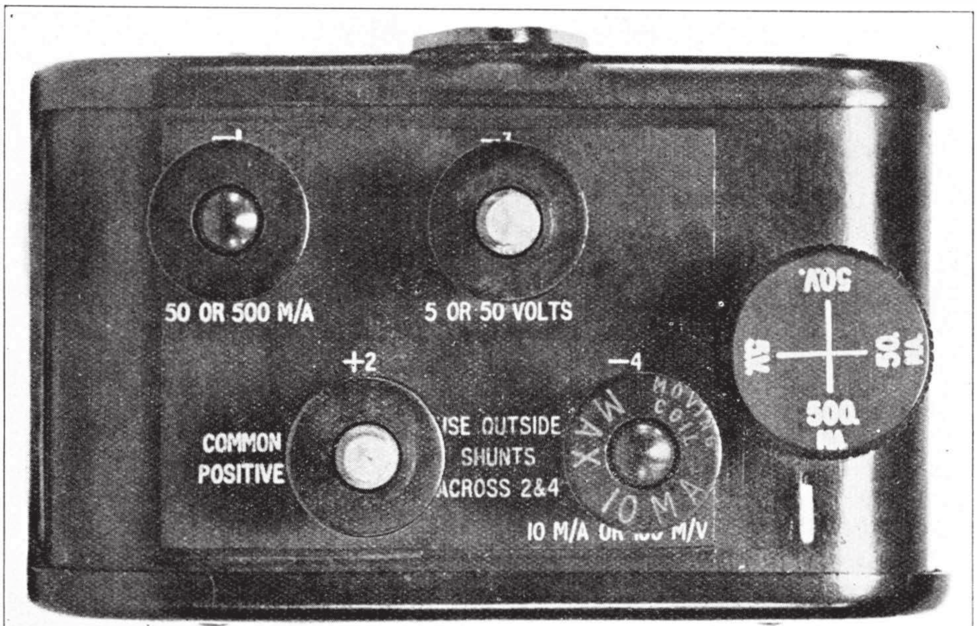


FIG. 2.—PLAN OF TOP, SHOWING TERMINALS.

An interesting feature which conduces to the sensitiveness of the instrument is the low resistance of the moving coil circuit, *i.e.*, 10 ohms, which is made up as follows:—

Moving coil (copper wire) ...	3.00 ohms.
Two hair springs (phosphor bronze)	1.30 ,,
Fuse (Eureka)	0.70 ,,
Series resistance (manganin)	5.00 ,,
	10.00 ,,

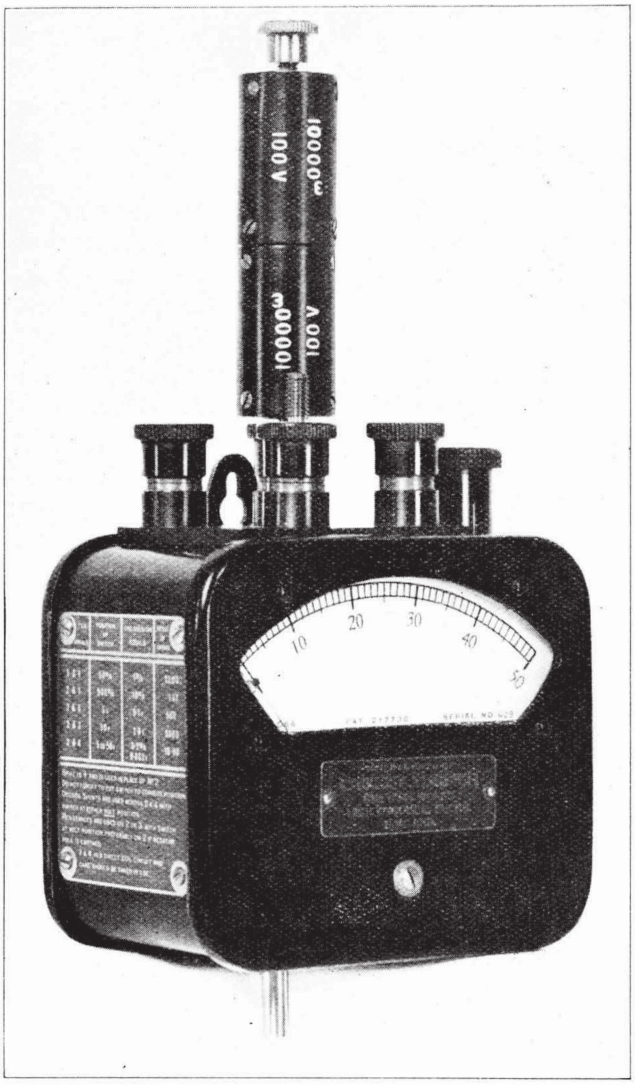


FIG. 4.—DETECTOR WITH BOTH MULTIPLIERS FITTED ON TERMINAL 3.

The make-up of the circuit results in a low overall temperature coefficient; the error due to temperature variation as an ammeter or voltmeter is 0.13% per degree Centigrade as against 0.427% were the circuit made up of copper wire. When used as a voltmeter the temperature variation is, of course, negligible.

The equipment of shunts and resistances consists of one 5A and one 25A shunt and two 10,000-ohm multipliers.

The shunts are so designed that they may conveniently be fitted across the moving coil terminals Nos. 2 and 4. Fig. **3** illustrates the 25A shunt fitted.

The multipliers may be screwed together in series and the threads of terminals Nos. 2 and 3 are elongated to accommodate one or both, depending on the range required. Fig. **4** shows both multipliers fitted to terminal No. 3. Terminal No. 2 should preferably be used for this purpose if the negative pole be earthed and terminal No. 3 if the positive pole be earthed, the reason being, of course, that it is desirable when working with the higher voltages that the internal connections of the instrument should approximate to earth potential.

A full scale deflection is given with 10 mA and the ranges of the instrument are given in the following table:—

Range.	Terminals.	Value per division.	Resistance in ohms.	Shunts and resistances in use.
Current.				
0—10 mA	2 & 4	0.2 mA	10.00	Direct on moving coil.
0—50 mA	2 & 1	1.0 mA	12.00	Internal shunt.
0—500 mA	2 & 1	10.0 mA	1.47	Internal shunt.
0—5 A	2 & 4	100.0 mA	0.0199	External shunt.
0—25 A	2 & 4	500.0 mA	0.004006	External shunt.
Volts.				
0—0.1 v.	2 & 4	.002 v.	10.00	Direct on moving coil.
0—5 v.	2 & 3	.100 v.	500.00	Internal resistance.
0—50 v.	2 & 3	1.000 v.	5000.00	Internal resistance.
0—150 v.	2 & 3	3.000 v.	15000.00	External resistance.
0—250 v.	2 & 4	5.000 v.	25000.00	External resistance.

The compound switch has four positions, which are 50 mA, 500 mA, 5 V and 50 V respectively. When multipliers are used the switch should be in the 50 V position. When external shunts are used the switch should be in either volt position. It will be seen that the range of the instrument lies between 0.2 mA and 25 A and between 2 millivolts and 250 V, a comprehensive range which renders it capable of performing a variety of tests.

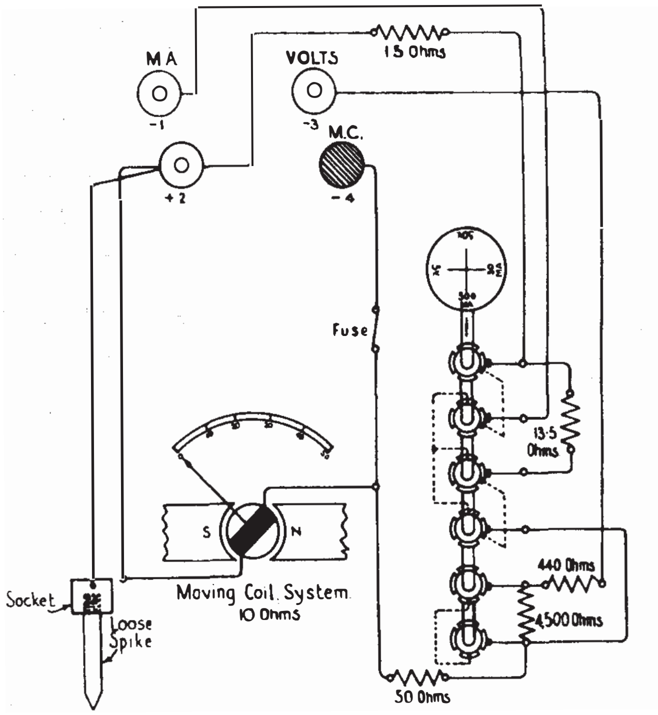


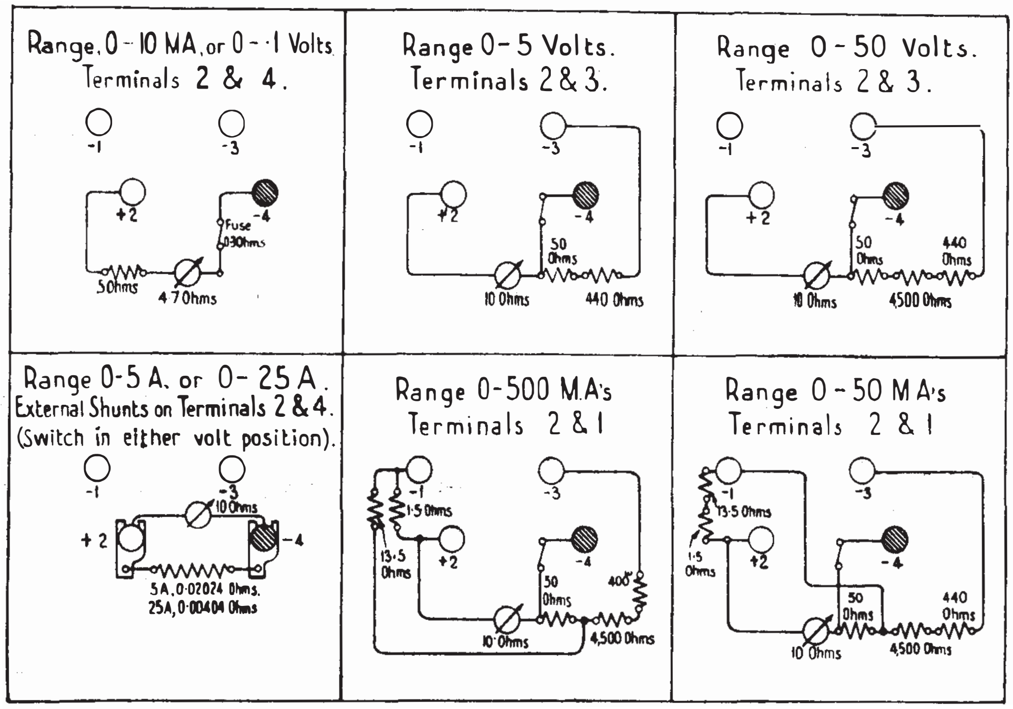
Fig. 5.—Internal Connections of Detector.

When used as a voltmeter the resistance is 100 ohms per volt. In exceptional cases where readings of over 250 volts may be required the range may, of course, be increased by 100 volts or upwards by the addition of the requisite 10,000 ohm multipliers. The voltage readings are to the Grade 1 standard, which is considered essential in view of the importance of the tests required to be carried out.

The internal connections are given in Fig. **5** and the theoretical connections in Fig. **6**, which are self-explanatory.

The zero may be adjusted by means of the screw provided. An instruction plate, giving particulars of scale readings and terminals to be used, etc., is mounted on the instrument. The case is of brass, black japanned, and the overall dimensions are 4″ × 3⅜″ × 2″ deep. The detector is accommodated in a leather case, which is slotted to permit of readings being taken without the instrument being removed, and is fitted with a shoulder strap. An additional leather case is provided for the external shunts and multipliers.

The moving system operates on dead hard steel pivots, which are coned with rounded


Range. 0 – 10 MA. or 0 – ·1 Volts. Terminals 2 & 4.

Range 0 – 5 Volts. Terminals 2 & 3.

Range 0 – 50 Volts. Terminals 2 & 3.

Range 0-5 A. or 0 – 25 A. External Shunts on Terminals 2 & 4. (Switch in either volt position).

Range 0-500 M.A's Terminals 2 & 1

Range 0 – 50 M A's Terminals 2 & 1

Fig. 6.—Connections between Terminals in various positions of Switch.

ends polished under a microscope. The pivot holes are fitted with sapphire jewels. The hair springs are made of phosphor bronze. The frame former is of insulated silver and is wound with copper wire of 5 mils diameter, insulated with single silk and baked in bakelite. The fuse wire is of 2 mils Eureka, which will fuse at 0.5 amperes, the fusing point of the moving coil being approximately 3 amperes. The external shunts are made of manganin wire and are carefully calibrated and interchangeable. The magnet is well aged and the scale accurately divided. The instrument is sufficiently robust to withstand all the ordinary use and most of the occasional abuse which portable instruments are more or less bound to receive. In this connection it is of interest to note the very light weight of the moving system, including the two hair springs, which is 0.7 gram or 10.801 grains as compared with the weight of the instrument which is 1 lb. 10 ozs. Altogether by its sensitiveness, wide range and adaptability it provides an efficient testing instrument eminently suitable to meet the many and varied requirements in the maintenance of telephone and telegraph apparatus, among which the following may be enumerated :—

- Low P.D. tests of power board and secondary cell bolted connections; fuse and switch connections. Tests of main earth connections.
- Cable sheath current tests.
- Tests of high voltage batteries used in conjunction with Repeater and Wireless Stations and Precision testing.
- Secondary Cell discharge readings.
- Resistance of power leads.
- Internal resistance of Primary Cells.
- Automatic exchange maintenance.
- Maintenance of Baudot and other machine Telegraphs.
- Checking calibration of power board instruments.

It is also suitable for panel mounting on power boards.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST MARCH, 1927.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
534,407	541	4,130	52,189	243	London	23,309	60,933	1,936,599	114,257
65,951	1,876	21,656	62,112	1,589	S. East	3,869	40,352	151,433	15,370
69,932	4,465	29,497	49,603	2,413	S. West	16,300	8,964	124,403	55,943
54,938	6,836	33,685	47,772	4,315	Eastern	19,214	33,448	79,927	79,095
87,773	8,678	43,683	55,275	3,496	N. Mid.	22,960	44,982	202,055	124,476
67,323	4,784	28,598	65,048	4,005	S. Mid.	12,957	21,013	133,562	88,875
54,046	4,790	29,099	49,322	2,575	S. Wales	5,787	24,916	97,206	69,757
92,741	8,219	25,338	47,230	4,957	N. Wales	12,826	39,413	214,944	59,633
144,021	1,602	17,013	42,484	2,804	S. Lancs.	12,717	75,696	428,377	46,299
85,327	6,061	29,809	44,479	3,504	N. East	10,612	40,401	194,868	71,419
57,916	3,622	24,224	36,034	1,708	N. West	8,402	31,707	139,978	38,049
43,625	2,531	15,691	23,378	2,653	Northern	4,595	11,511	87,843	53,424
19,649	4,769	6,884	12,933	335	Ireland N.	128	1,977	36,491	718
59,928	5,296	24,310	35,648	1,223	Scot. East	2,863	10,074	138,092	49,955
81,199	7,365	24,098	41,161	838	Scot. West	12,172	24,287	207,897	35,512
1,518,776	71,435	357,715	664,668	36,658	Totals.	168,711	469,674	4,713,675	902,782
1,479,800	72,723	355,078	657,124	36,146	Figures at 31st Dec., 1926.	166,401	448,109	4,013,916	867,514

SHEFFIELD'S AUTOMATIC EXCHANGES.

H. W. Dipple, A.M.I.E.E.

At midnight on March 5th, 1927, the the whole of the Sheffield Telephone area was simultaneously converted from Manual to Automatic working. A total of 11 Manual Exchanges were closed down and 9 Automatic Exchanges brought in service. A new Trunk Exchange and Manual Board in connection with the Automatic system was also cut into service.

The exchanges concerned in the transfer, to-

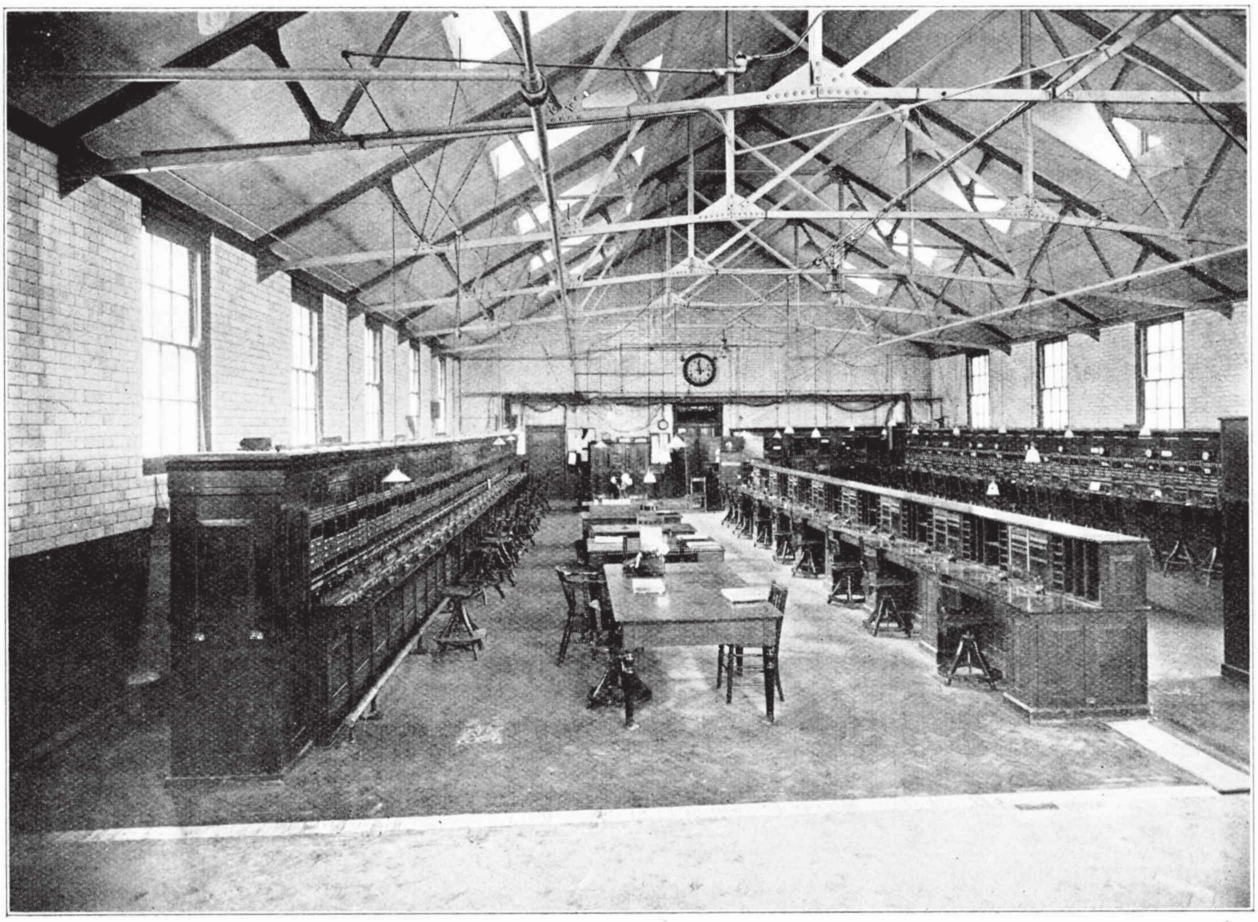


Fig. 1.—Trunk Exchange, Sheffield. A and J.E. positions on left. Enquiry in centre.

gether with their initial and ultimate equipment, are as follows:—

Exchange.	Initial Equipment.	Ultimate Capacity.	Remarks.
Central ...	6300 lines	9000 lines	
Broomhill ...	2800 ,,	3500 ,,	
Sharrow ...	1800 ,,	2600 ,,	
Beauchief ...	1200 ,,	1900 ,,	
Attercliffe ...	1000 ,,	1500 ,,	Satellite on Central.
Owlerton ...	800 ,,	1200 ,,	,, ,, ,,
Ecclesfield ...	200 ,,	300 ,,	,, ,, ,,
Woodhouse ...	200 ,,	300 ,,	,, ,, ,,
Oughtibridge ...	100 ,,	100 ,,	,, ,, ,,
West (Relief to Broomhill) ...	—	—	Closed; and lines transferred to Broomhill.
South (Relief to Sharrow) ...	—	—	Closed; and lines transferred to Sharrow.

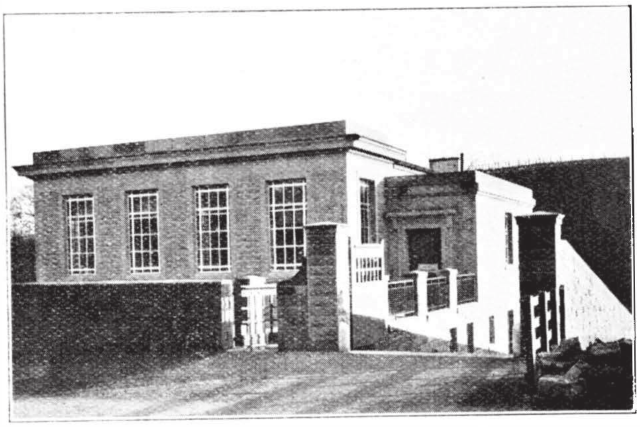


FIG. 2.—BEAUCHIEF EXCHANGE EXTERIOR.

The ultimate numbering scheme for the area is as follows:—

Central	... ...	20000—28999
Ecclesfield	... ...	40000—40299
Woodhouse	... ...	40400—40699
Oughtibridge	...	40800—40899
Attercliffe	.. ...	41000—42499
Owlerton	... ...	43000—44199
Sharrow	... ...	50000—52599
Broomhill	... ...	60000—63499
Beauchief	... ...	70000—71899

The conversation of the Sheffield area represents the third of what might be termed the "large scale transfers" undertaken by the Post Office within the past two years. The transfers at Leeds and Edinburgh were described in the April, 1926, and January, 1927, issues of this Journal, the Edinburgh transfer being then

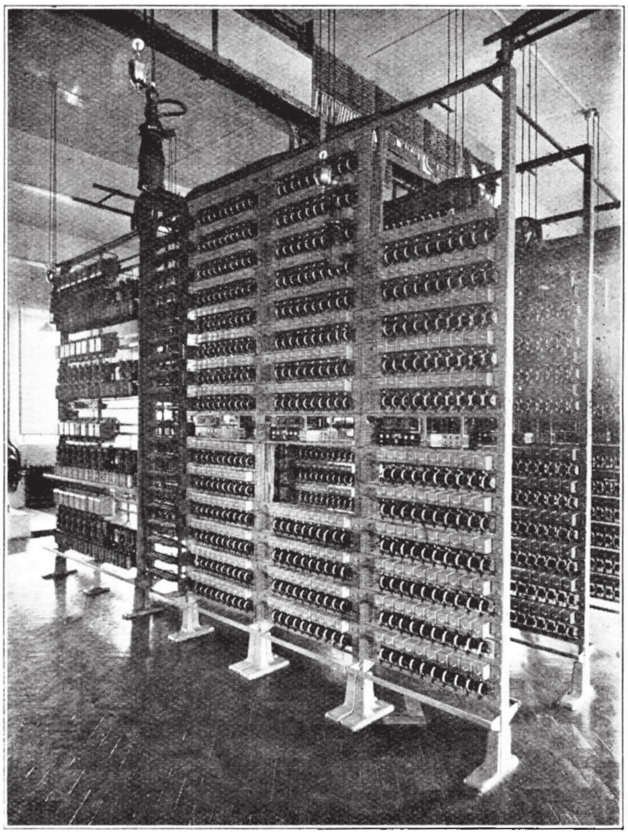


FIG. 3.—BEAUCHIEF EXCHANGE. FIRST PRESELECTOR RACKS AND FINAL SELECTOR RACK WITH SECTIONAL I.D.F.

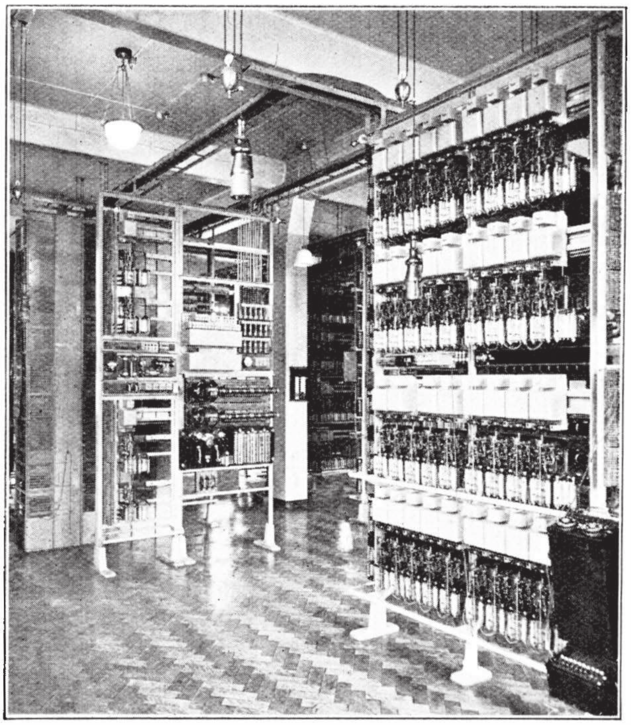


FIG. 4.—SHARROW EXCHANGE. FIRST SELECTOR RACK AND MOTOR-DRIVEN INTERRUPTERS.

referred to as the largest ever undertaken by the British Post Office. At Sheffield, however, while the total number of Exchange lines dealt with was less than at Edinburgh, the larger number of Exchanges to be dealt with simultaneously and the complexity of the transfer arrangements make the transfer the largest and most difficult yet undertaken by the Post Office Engineering Department and probably constitutes a world's record. The transfer of nine exchanges simultaneously is a difficult task in itself, but the rearrangements of Exchange boundaries which were carried out at the same time increased the difficulties considerably, and the Sheffield Engineering force is to be congratulated on the successful termination of a long and difficult task.

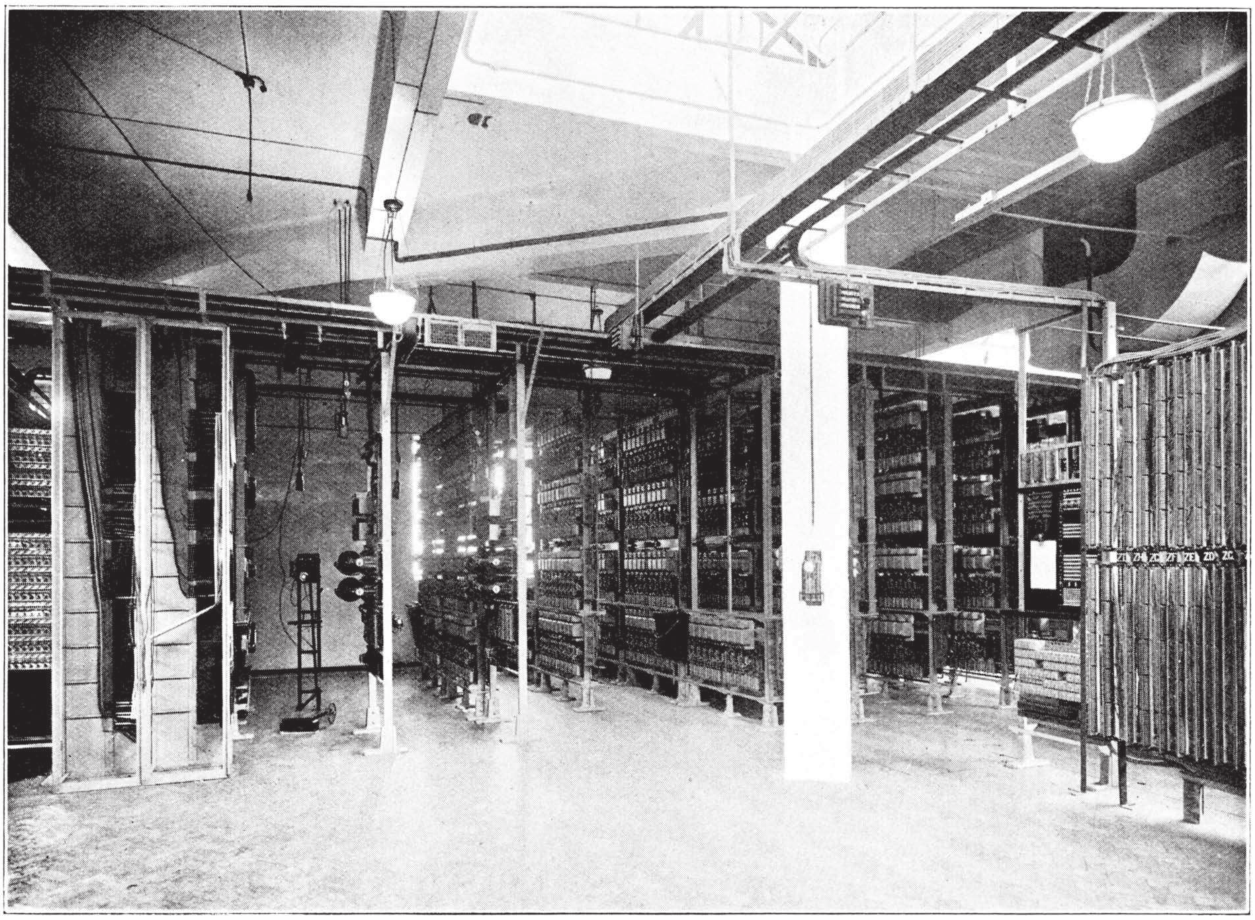


Fig. 5.—Central Exchange, Sheffield. First Selector Racks.

The transfer scheme included the following change of lines from one area to another :—

Central to Broomhill ...	234 lines.
,, ,, Attercliffe	181 ,,
,, ,, Sharrow ...	112 ,,
,, ,, Owlerton	29 ,,
,, ,, Woodhouse	6 ,,
,, ,, Beauchief	5 ,,
,, ,, Oughtibridge	4 ,,
Sharrow to Beauchief	2 ,,
Attercliffe to Woodhouse	1 ,,

In addition to these circuits, a total of approximately 1200 lines were transferred from South and West to Sharrow and Broomhill Exchanges. The total number of Exchange lines dealt with was 9928, and after the rearrangements the distribution of circuits was as follows :—

Central	4646
Broomhill	1847
Sharrow	1141

Beauchief	763
Attercliffe	661
Owlerton	575
Woodhouse	123
Ecclesfield	115
Oughtibridge	44
	9915
Rural party lines on Manual Board	13
Total	9928

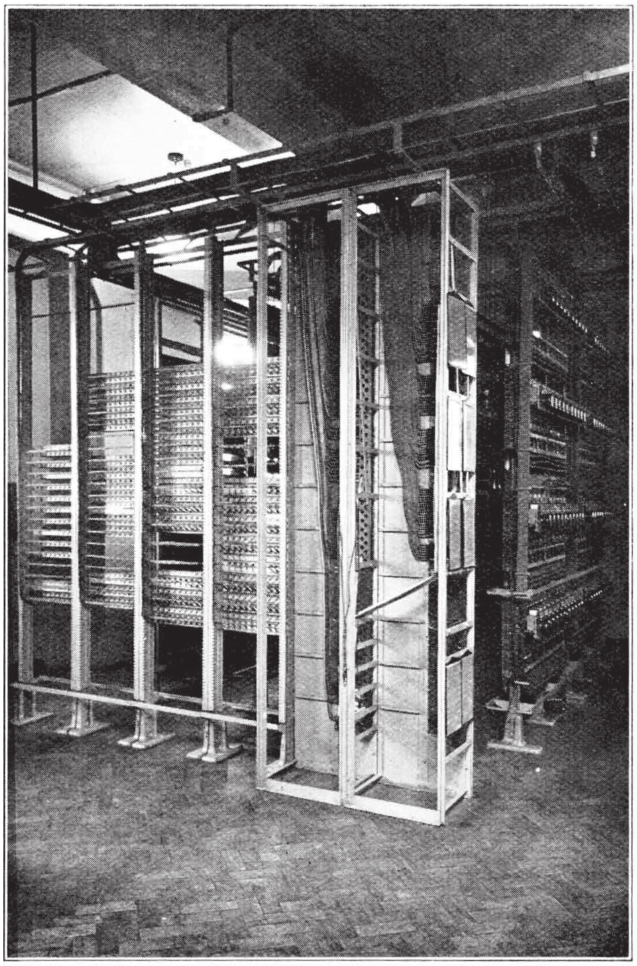


Fig. 6.—Central Exchange, Sheffield. Rear view of Traffic Meter Racks and Cross-Connection Frame.

The automatic switching plant was manufactured and installed by Messrs. Siemens Bros. & Co., and is of the well known No. 16 type. Attercliffe and Owlerton satellites are equipped with Discriminating Selectors which allow of local calls being completed within the Exchange. Ecclesfield, Oughtibridge and Woodhouse Exchanges are equipped as ordinary satellites without the Discriminator scheme, all local calls being completed *via* Central over an Incoming Junction. The plants at Central, Sharrow, Beauchief, Owlerton, Woodhouse and Oughtibridge are housed in new buildings provided by the Office of Works, and at Attercliffe, Broomhill and Ecclesfield in existing buildings adapted to automatic requirements. The Trunk Exchange and Manual Board equipment is

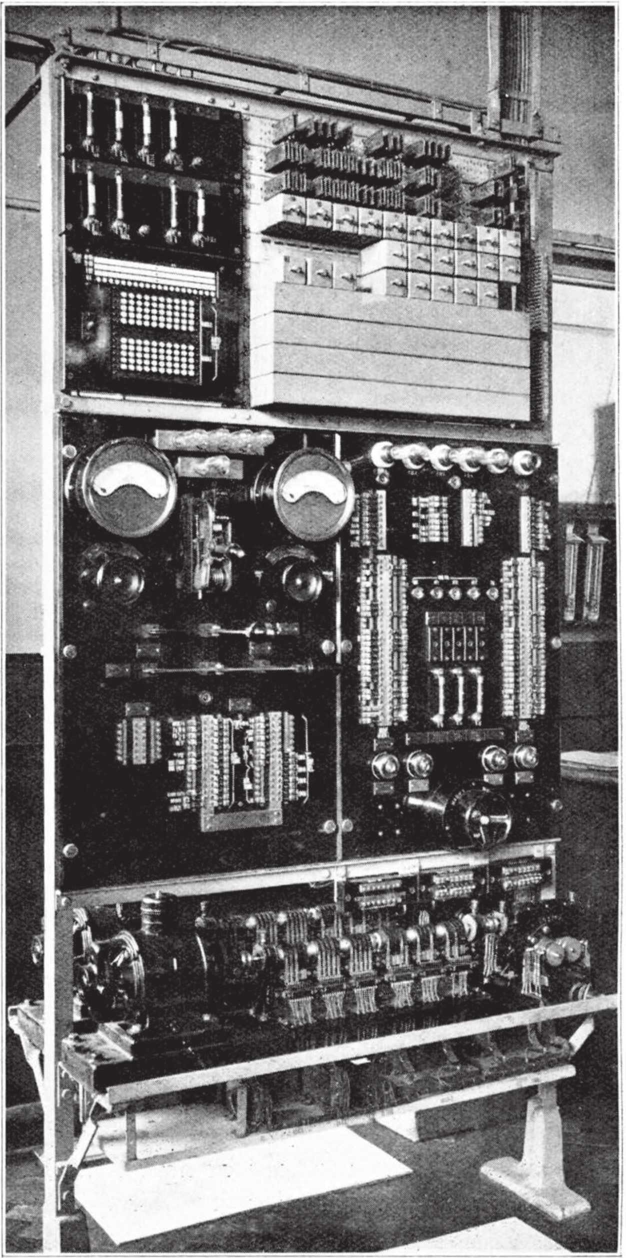


Fig. 8.—Power Panel. Owlerton Exchange.

accommodated at the Head Post Office and includes the following:—

22 Long distance positions.
3 Order wire positions with Key Sender Impulse equipment.
3 Jack-ended junction positions.
21 A positions for Toll calls and calls from Coin Box lines.
1 Service P.B.X. position.
16 Enquiry positions.

Portions of the equipment and buildings are illustrated as follows:—

Fig. **1** shows the Trunk Exchange, the A. and J.E. positions being on the left, and the Enquiry positions in the Centre.

Fig. **2.** The Exterior of Beauchief Exchange.

Fig. **3.** 1st Preselectors, Final Selectors and Sectional I.D.F., Beauchief Exchange.

Fig. **4.** 1st Selector Rack and Motor-driven Interrupter machines, Sharrow Exchange.

Fig. **5.** 1st Selector Racks, Central Exchange.

Fig. **6.** Rear view of Traffic Meter Rack and cross-connection frame, Central Exchange.

Fig. **7.** 8 Position Test Desk, Central Exchange.

Fig. **8.** Power and Fuse Panel and Interrupter Machines, Owlerton Exchange.

Fig. **9.** General view of 1st Preselectors and Repeater Rack, Woodhouse Exchange.

Fig. **10.** Power Panel and Mercury Arc Rectifier Unit. Woodhouse Exchange.

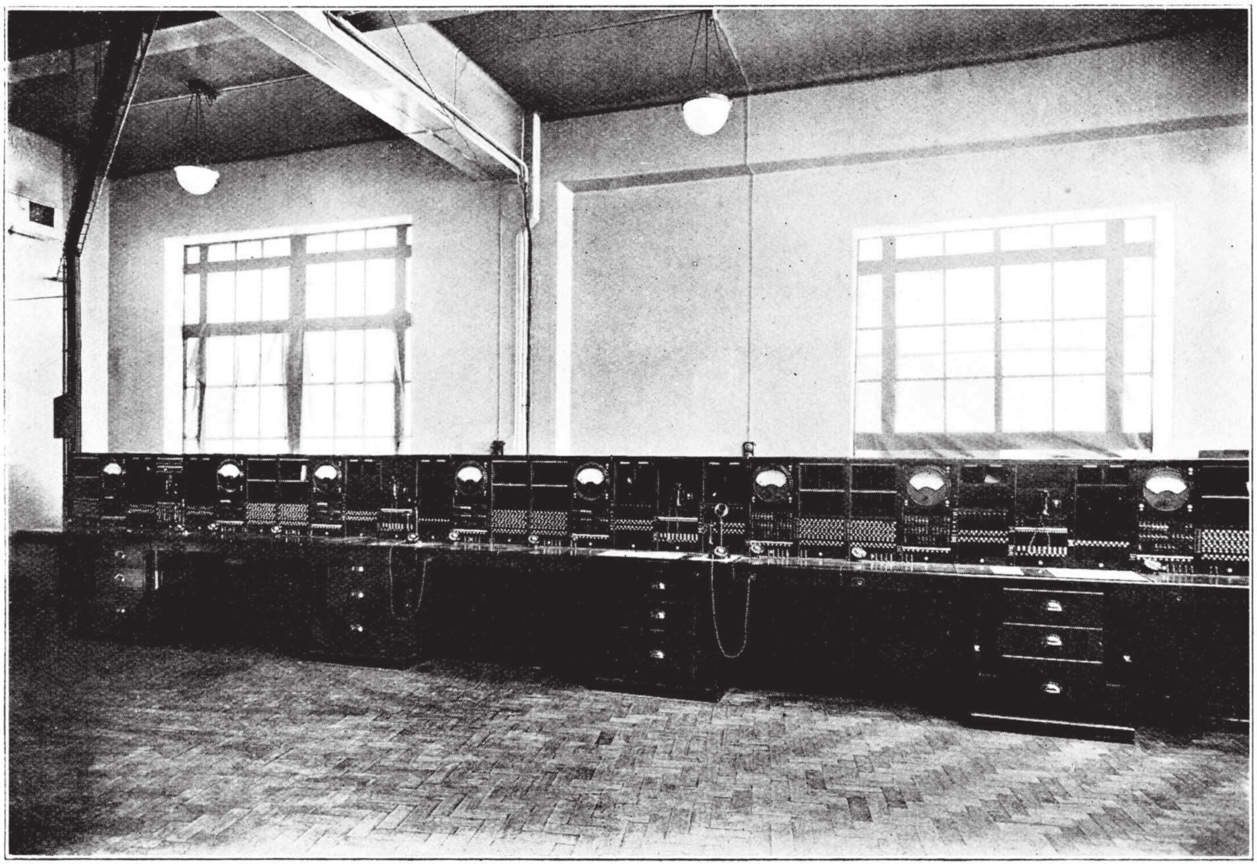


FIG. **7.**—CENTRAL EXCHANGE, SHEFFIELD. TEST DESK, 8-POSITION.

A few hours prior to the main transfer, a large number of junctions and Trunks were transferred to the new Trunk Exchange, the remainder going over at midnight. Promptly at midnight the signal was given to commence cutting out at the old Exchanges and in about 10 minutes the transfer was complete. Immediately after the transfer, a total of 293 "permanent loops" on the 9 Exchanges was observed, this being 2.9% of the working lines. As it was subsequently ascertained that a considerable number of these P.L.'s were due to subscribers' errors at P.B.X. switchboards, or at the old telephone, it is clear that the transfer can be regarded as extremely satisfactory, and quite up to that high standard of efficiency at which all Post Office Engineers aim in carrying out such schemes.

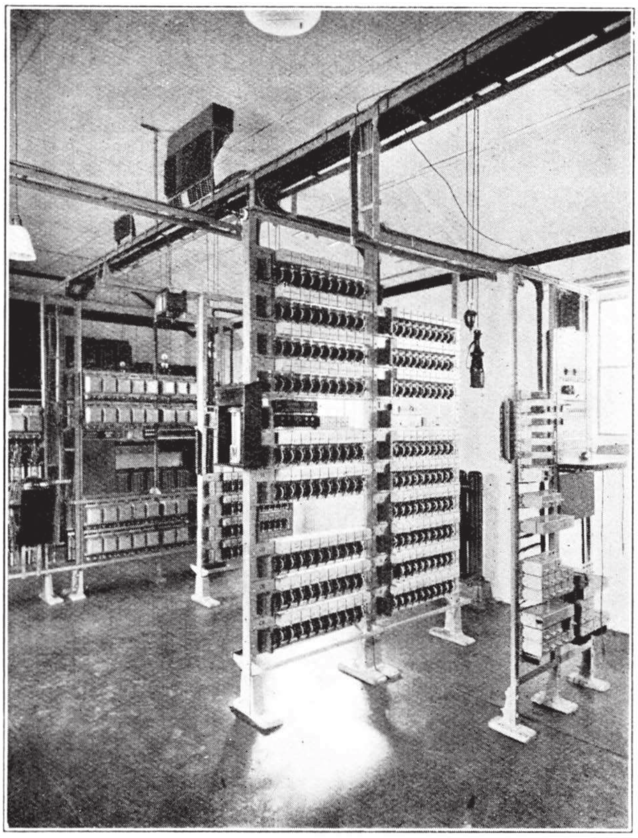


FIG. 9.—WOODHOUSE EXCHANGE. FIRST PRESELECTOR AND REPEATER RACK.

On the Monday and Tuesday following the transfer, considerable traffic congestions were experienced, the greater part of which was due to slowness and misoperation of the new telephone on the part of the subscribers. This gradually righted itself, and by Wednesday the traffic was flowing satisfactorily.

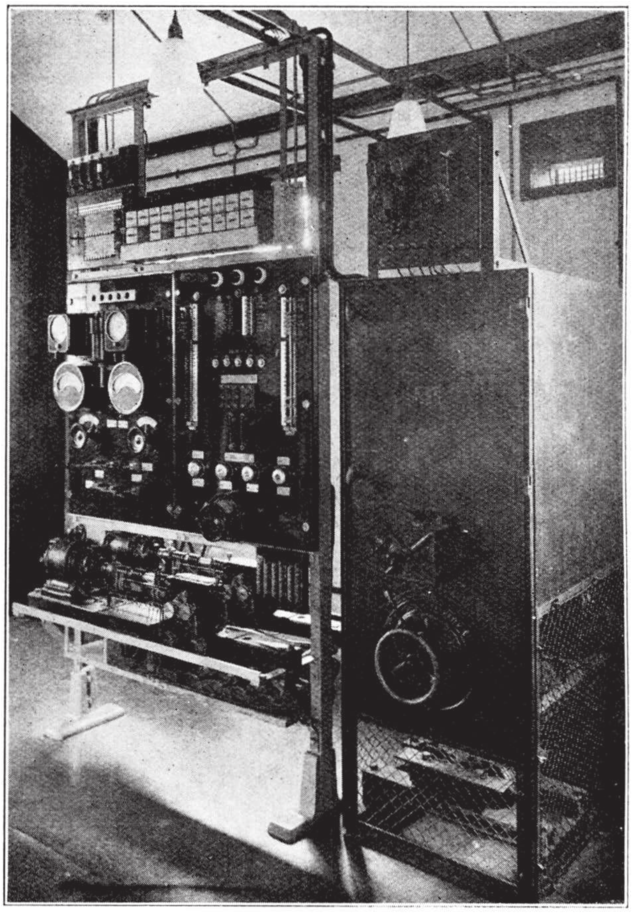


FIG. 10.—WOODHOUSE EXCHANGE. POWER PANEL AND MERCURY ARC RECTIFIER UNIT.

Thanks are due to Messrs. Siemens Bros. & Co. for the photographs with which this article is illustrated.

MESSRS. SIEMENS' AUTOMATIC IMPULSE SENDER.

[*From a lecture by* J. INNES, B.Sc., *before the Scotland East Local Centre.*]

INTRODUCTORY.—The general practice in the Department for handling traffic to Automatic Exchange areas from outlying Manual Exchanges having direct Junctions, is to provide dials on each operator's position, so that with very little additional cost at the outgoing end each operator may obtain the called subscriber without the intervention of a second operator. It is possible, therefore, to reduce the size of the Manual Board in an Automatic Area to a relatively great extent. There are, however, limits to the length of circuit over which dialling can be considered reliable, and other arrangements must be made in cases where dialling would not be satisfactory. Such cases may be divided into two classes:—

(1) Small groups which can be operated economically on a manual basis, and
(2) Large groups where order wire working with some form of machine dialling is essential.

The Key Sender associated with an Order Wire position has been designed to meet the requirement of the latter case, and is the subject of this paper.

" B " Position Equipment.—In the Edinburgh Area this position is of the Cordless type, provision being made for an ultimate capacity of 40 Order Wire Junctions, the equipment installed being for 25 circuits.

Each Junction is led through a break jack on the position, so that any Junction may be brought into use as an Order Wire in the event of the normal circuit becoming faulty. A pair of plugs and cords is provided for this purpose. The Junctions are continued from the break jacks to the Automatic Exchange, where each is terminated on a Switch equivalent to a First Selector.

Cord Circuit.—The transmission bridge and supervisory facilities which are normally located in the cord circuit are provided for each Junction as part of its equipment and are located on the Special Apparatus Rack. The " B " operator has no control over the Junction when the call is through, and the usual supervisory signals are transmitted direct to the " A " operator who has complete control of the call.

Assignment Key and Supervisory Lamp.—An Assignment Key and Supervisory Lamp are provided for each Junction and mounted on the keyshelf. The " B " operator presses the appropriate Assignment Key when she names the Junction to be used by the " A " operator and the glowing of the Supervisory Lamp gives her the necessary information regarding Engaged Junctions. Certain other supervisory facilities are referred to later.

Digit Keys.—Five strips of ten digit keys, engraved 1 to 0, are fitted to replace the dial, one strip for each of the Ten Thousands (N), Thousands (M), Hundreds (H), Tens (T) and Units (U) digits used in the five figure system.

Each strip of digit keys is wired to the bank contacts of three preselectors (one in each of the three senders); but the connections are made in inverse order, thus No. 1 Key is connected to No. 10 contact, No. 2 Key to No. 9 contact, No. 3 to No. 8 contact and so on. The effect of pressing a key is to mark the particular contact to which the associated wipers will step and come to rest. When sending commences, the preselectors return to their normal contacts and the number of steps taken represents the number set up by the operator.

Sender Supervisory Facilities.—The operator is provided with the following facilities for the Three Senders which form the complete Impulse Sender:—

(1) *Sender Engaged Lamp.*—To indicate the sender in use. It also indicates if there is any holding up of a Sender due. for example, to the " A " operator not having taken up the Junction. In such a case the Sender Lamp flashes.
(2) *Sender Disconnect Key.*—One per sender is fitted, and the Key is used to cut out any faulty sender.
(3) *Sender Release Key.*—One per sender is fitted. It is used for disconnecting a sender from a Junction with which

it has been engaged for an abnormal time. The indication of this is the flashing of the Sender Engaged lamp and the operator can release the Sender by depressing this Key.

(4) *Cancel Key.*—Should an operator depress a wrong digit Key and immediately realise the fact, she may return the sender to normal and again set up the number. If operated before the sender has completed sending out impulses *and before another assignment key is depressed,* all automatic switches brought into use will be returned to normal, the sender remaining linked with the Junction.

(5) *Reassignment Key.*—If the operator presses the wrong assignment key and realises it before completing the set-up of the call, she will release the Junction from the sender by operating the Reassignment Key. The correct Assignment Key can then be operated and the call set up. If the error is not observed until the call has been set up, the operation of this Key, *if done before another Assignment Key is operated,* will release the switches brought into use, at the same time releasing the sender from the Junction.

Holding up of Calls.—Provision is made in the Sender to hold up the last digit until the "A" operator takes up the Junction, so that the call will not mature before the calling operator is ready to take it. False calls to subscribers are clearly impossible. The lamp flash indications to the "B" operator have already been referred to.

Impulse Sender Equipment.—The Impulse Sender consists of (1) an Assigner, (2) Sender Junction Seeker, (3) Sender Controller and (4) Sender.

(1) *The Assigner.*—Two are provided with switching facilities to bring either into use. A standard preselector is used for each, the "A" and "C" banks being used, and two controlling relays AP and AQ. The purpose of the Assigner is to bring the three Senders into use in sequence and it stands on the first free Sender in the machine.

(2) *Sender Junction Seeker.*—These are standard preselectors, the number used depending on the number of Junctions terminated on the position. With 40 Junctions, 4 preselectors are used, the "C" bank contacts being wired up to the Assignment Keys associated with each Junction so that the depression of an Assignment Key marks the corresponding bank contact and the Junction Seeker drives until the marked contact is reached. The Junction is thus linked up with a Sender.

(3) *Sender Controller.*—The function of the Controller is to ensure that the impulse trains are sent out in the correct order and to regulate the pause period between each train, to give selectors time to hunt for free outlets to the next rank of switch. Standard preselectors are used in this case also.

(4) *Sender.*—Each of the three Senders consist of 5 preselectors corresponding to the five digits N, M, H, T and U, used in the Edinburgh system. The "A" banks are wired to the digit keys on the "B" position as already described. The function of the other banks is described in the details of operation.

There are two speeds used in the drive circuits in the Impulse Sender, viz., 40 and 10 Impulses per second. The two speeds are used as follows:—

40 *Impulses per second.*

Junction Seekers searching for Assigned Junction and returning to normal.

10 *Impulses per second.*

Sender Controller.

Sender Switches returning to normal (*i.e.,* sending out impulses).

A special Motor Interrupter Machine is provided with the Impulse Sender to give the high and low speed drives. All leads are brought out to knife edge contacts so that the spare machine can be brought into use quickly.

Marking Condensers.—Although the Senders drive at 40 Impulses per second, it is possible that an operator would have released a digit key before the wipers had reached the corresponding contact, and failure would result. To guard against this and to avoid operators having to hold down the digit keys, each contact has a marking condenser associated with it, and which is charged when the key is depressed. The condensers are momentarily short-circuited before a number is set up to guard against wrong numbers being set up due to a partially charged condenser.

Night Start Facilities.—Provision is made for starting up the machine at night should the traffic warrant the bringing into use of the " B ' position.

Alarms.—A motor stopped alarm is given if the motor stops or fails to start. The usual Fuse Alarm is of course provided.

An additional safety precaution is provided to cut off battery from the interrupter bus-bar immediately the motor is stopped. This protects the spring sets and magnet windings from continuous current.

Operating Procedure. — On receipt of a request for a number from a distant " A " operator, the " B " operator assigns a Junction for the call and at the same time depresses the corresponding Assignment Key. With the operation of this key the bank contact in the Sender Junction Seeker is marked and as the Assigner stands on the first free Sender, the Seeker will drive until the Junction has been picked up. A Sender has thus been linked up with the assigned Junction and the corresponding Sender Engaged Lamp will glow.

The " B " operator will now set up the "called number" by depressing the appropriate digit keys and with the depression of the last key the sender will commence to send out the impulse trains to the Automatic Switches. (The digit keys may be depressed in any order or simultaneously).

By this time the " A " operator should have taken the assigned Junction and the Supervisory Lamp will glow steadily if she has done so, and the whole of the digits will pass out of the Sender which will again become free to take other calls.

Until the " A " operator has taken up the assigned Junction a slow flash (standard interrupted earth) will be given on the Supervisory Lamp. The last digit of the train of impulses is held up by the Sender until the " A " operator has taken up the assigned Junction, and the Sender Engaged Lamp will flash to show the position to the " B " operator.

If the " A " operator picks up the wrong Junction, a fast flash or flicker (10 per second) is given on the Supervisory Lamp of the Junction actually taken, while slow flash as described above will be given on the assigned Junction. If the " B " operator has not assigned another Junction before observing this, she may rectify it by depressing the Re-assignment Key, pressing the key associated with the Junction actually taken and again setting up the number.

With the passing out of the impulses from the Sender, the Sender is released and the " B " operator drops out entirely, the control of the Junction remaining with the " A " operator, who releases the Junction and automatic switches with the withdrawal of the plug at the distant Exchange.

Circuit Operations.—The diagram referred to throughout the description of the circuit operations is on the detached contact principle and refers to one Sender. It may be taken that there are identical Preselectors, Relays and Contacts for each of the other two Senders.

For simplicity, the diagram has been prepared without reference to the actual location of the apparatus. Relays are named by letter and are followed by a number representing the number of Contacts. All Relay Contacts are shown in their normal (unoperated positions) and all Preselectors are shown on their normal Contacts.

The Assigner.—The two Assigner mechanisms consisting of the " A " and " C " banks of the duplicate preselectors have been shown. The driving magnets are lettered D. The two relays controlling the Assigner operations are AP 2000^{ω} and AQ, three windings, each 3000^{ω}.

The three Contacts (Nos. 2, 5 and 8) on the " A " banks are multipled together and wired through Q Contacts (referred to later) to the normal contacts of the D banks of the Sender Junction Seeker.

The corresponding contacts on the "C" banks are each wired (in parallel with one winding of the AQ Relay) through their Sender Disconnect Key to the back of a contact S_1 in each Sender Controller. If a Sender is free, this contact is connected to earth through the moving spring and is "dis" while a Sender is engaged.

Taking the "Free Sender" case first and remembering that the Assigner stands on the first free sender, the AP and AQ relays will both be operated as they have a path to earth *via* the S_1 contact. Contacts AP_1 and AP_2 will therefore be in the operated position and the drive circuit of the Assigner will be disconnected.

If now the operator depresses an Assignment Key, a Q Relay will be operated and the closing of the Q^1_1, Q^2_1, Q^3_1 or Q^4_1 contact will complete the drive circuit of the Junction Seeker, as the operation of the AP contacts prepared this condition by providing the necessary earth. (This point is referred to in detail in the Junction Seeker operations).

The AQ Contacts open and thus disconnect the earth from the normal Contact of the "C" bank, and this condition will be maintained as long as there is one free Sender.

Immediately all the digits have been passed into the Sender, its S_1 contact will be operated and Relay AP will release (Relay AQ will also release if both other Senders are engaged). With the release of AP, the AP contacts restore to normal and the drive circuit is completed from Battery through the Interrupter Spring Set, driving Magnet D to earth *via* AP_1 or AP_2. The wipers will be stepped round the banks until they reach a contact on which there is an earth, when Relay AP will be operated and the drive is cut. Such an earth will only be found on a "free" Sender *via* its S_1 contact, or if all Senders are engaged at the normal contact on the "C" bank.

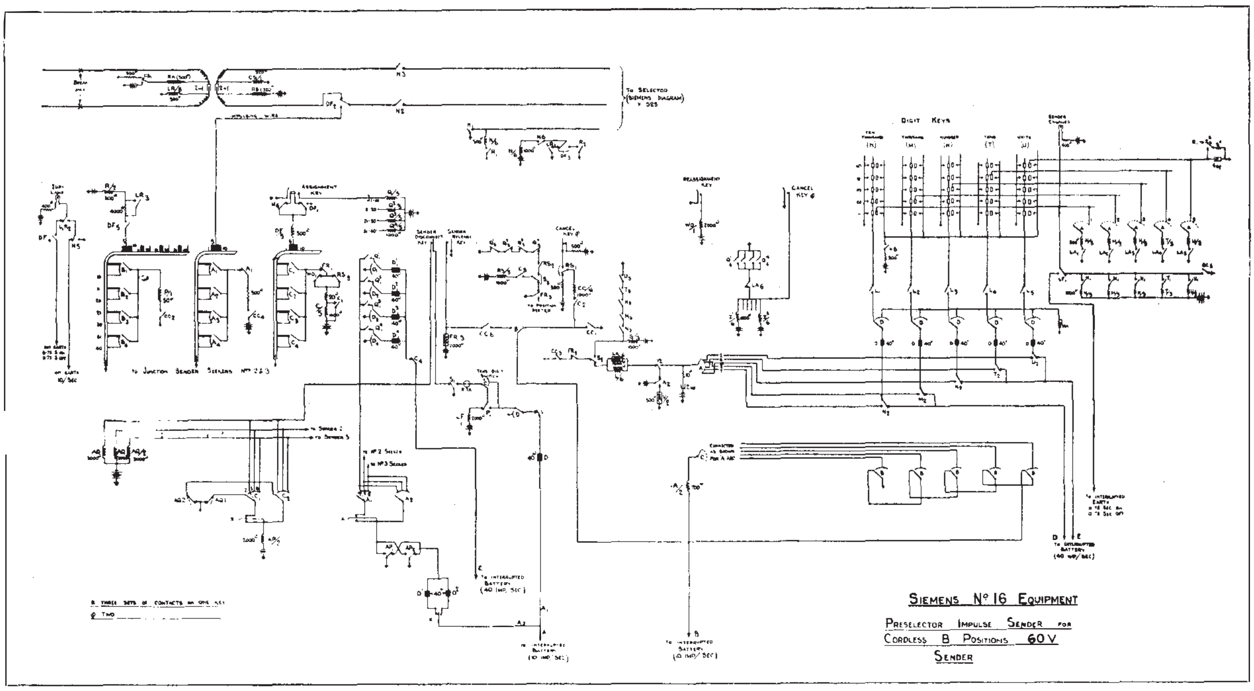

Digit Keys
Cancel Key
To Selector (Siemens Diagram)
To interrupted battery (40 int/sec)
To interrupted earth
Siemens No 16 Equipment
Preselector Impulse Sender for
Cordless B Positions 60V
Sender

FIG. 1.

In the latter case, immediately a Sender becomes "free" the AQ Relay will be operated, thus releasing AP and again bringing in the drive to take the wipers to the "free" Sender.

It will be clear that the Senders are taken in strict rotation. Unless there is any unnecessary holding up of a Sender due to the "A" operator not taking up the Junction, there is little likelihood of all three Senders being engaged. In the case of the digits 27999 being set up, the approximate times may be taken as follows:—

	Milli-seconds.
Operator assigns Junction and sets up number	3000
Sender steps to marked Contacts ...	500
Sender sends out 36 Impulses at 10 per second	3600
4 Pause periods between digits at 850 milli-secs.	3400
Total	10500

Say, 10.5 seconds.

This number represents practically the maximum number of impulses on the present numbering scheme and the time shown could be taken as the maximum period for which a Sender is engaged under normal conditions. The 3 seconds for assigning the Junction and setting up the number is probably on the low side, as it represents calls set up at the rate of 20 per minute or 1200 per hour, a speed never likely to be maintained. Even at this rate, however, the operator will take 9 seconds to set up three calls, and making allowance of 1.5 second to cover the slight interval between two calls, the first Sender will be free ready for the fourth call.

Sender Junction Seeker Operation.—The diagram shows four Relays (Q^1 to Q^4) associated with the Assignment Keys, one Relay being provided for each group of ten Junctions. The circuit of Junction No. 5 is shown on the diagram and the depression of the Assignment Key No. 5 causes Q^1 to operate from battery *via* the back contact of Key, contacts DF_1 and N_4 and front contact of Key to earth. The depression of the Key also applies an earth to the No. 5 bank contact of the C Arc.

(1) *With the operation of* Q^1.

Contacts Q^1_1, Q^1_2, Q^1_3 in the drive circuits of the three Seekers are closed. Assuming No. 1 Sender has been assigned the closure of Q^1_1 will complete the drive circuit from interrupted battery, C_4, Drive Magnet D^1_1, Wiper D, Q^1_1, A arc and wiper of the Assigner and contact AP_1 or AP_2 to earth.

Q^1_4 operates Relays " Z " and the " Z " contacts short-circuit the marking condensers to ensure that there is no partial charge.

Q^1_5 opens to release the RS relay in the Sender already in use. When No. 5 contact is reached, Relays C and DF will operate in series.

(2) *When DF operates,* contact DF_1 gives a holding earth for both relays DF and C against the release of the Assignment Key.

DF_2 connects the impulse wire from the Sender to the B wire of the Junction.

DF_3 prepares the circuit of Relay N in Junction.

DF_4 connects interrupted earth to the Supervisory Lamp circuit.

DF_5 prepares a circuit for Relay R in Junction and P in Seeker.

(3) *When Relay C operates*

C_4 cuts the drive circuit.

C_1 short-circuits the 1000^{ω} coil of C marking No. 5 engaged to the two other Senders.

C_2 completes a circuit to operate Relay CC *via* the normal Contact and " B " wiper of the Sender Controller to earth at the " B " wiper of the N digit switch in the Sender.

C_3 completes a circuit for Relay RS in the Sender Controller, Battery, Relay RS, C_3, S_3, FR_3 to earth.

C_5 provides an earth for the Night Start Relay operative when the Sender is not continually in use. This is shown on the diagram of the Motor Interrupter.

(4) *When Relay CC operates.*

CC_1 completes a locking earth for CC.

CC_2 completes the circuit for the operation of Relay R in the Junction circuit from Battery through Relay R, 4000^{ω} Spool, DF_5, B arc and wiper of Seeker Relay P and CC_2 to earth. (Note Relay P does not operate until 4000^{ω} spool is short-circuited by " A " operator taking up the Junction).

CC_3 completes a circuit for operating Relays L and LA in parallel (Battery A_2, V_2, Relays L and LA, S_2, FR_2, CC_3 to earth).

CC_4 connects Battery through 500^{ω} Spool and Contact A, to Impulsing wire and thus through " B " wire of Junction to the Selector.

CC_5 prepares the circuit for the holding coils of Relays N, M, H, T, and U, and lights the Sender Engaged Lamp *via* Contact LF.

CC_6 prepares a circuit for Relay FR to release the Sender when the sending out of the digits has been completed.

(5) *With the operation of RS:*

RS_1 changes over; but CC does not release.

RS_2 prepares a holding circuit for RS after S operates *via* the Q_5 Contacts.

RS_3 opens, leaving Relays C and DF dependent on the circuit *via* WO_1.

(6) *Relays L and LA in operating prepare the following circuits:—*

LA_1 to LA_5 prepare the circuits of the Digit Switches N, M, H, T and U on the " A " arcs in the Sender.

LA_6 opens the "Z " Relay circuit to remove the short-circuit from the marking condensers applied when Q^1 was operated.

L_1 to L_5 prepare the drive circuits of the Digit Switches *via* the normal contact on the " D " arcs.

L_6 connects battery to the right hand springs of the Digit Keys.

(7) *Junction Circuit Operation.*

With the operation of Relay R, Contact R_1 completes the circuit of Relay N on the C wire of the Junction to the Selector and N operates, while R_2 prepares a holding circuit for N.

N_1 applies an earth to the C wire to hold the T Relay in the Intermediate Selector used in this case as a 1st Selector.

N_2 and N_3 extend the A and B wires to the Selector and as the changing over of DF_2 (see (1)) has connected battery from the Seeker to the B wire, the A Relay in the Selector will be operated and the switch prepared to receive impulses.

N_4 opens the Assignment Key circuit, leaving DF dependent on its holding earth *via* DF_1.

N_5 prepares a circuit for the Supervisory Lamp.

N_6 completes the holding circuit of the 1000^ω coil of N already prepared at DF_3—See (1)—and R_2.

When the " A " operator takes up the assigned Junction, Battery is fed over the B wire and LR operates, and

LR_1 provides an alternative holding circuit for N when DF releases with the dropping out of the Sender.

LR_2 completes the circuit of the Supervisory Lamp which will glow.

LR_3 short-circuits the 4000^ω spool to allow Relay P to operate in the Sender.

It should be noted that until the operator picks up the Junction, Interrupted earth is connected to the lamp circuit *via* DF_4 and LR_2 and slow flash will be given on the Supervisory Lamp. Later, when the sending out of the call has been completed, the CS Relay will be operated over the called subscriber's loop and CS_1 applies Battery to the A wire, thus giving standard supervisory signals to the " A " operator. If the called subscriber be engaged, busy flash will be transmitted to her by intermittent operation of Relay CS.

If the " A " operator takes up the wrong Junction, the LR Relay in the Junction actually taken will be operated and LR_2 changes over, and the Supervisory Lamp on the Junction taken will flicker due to the connection of Earth 10 times per second.

(8) *Sender Controller and Sender Operations.*

Although these operations take some time to describe, they take place practically instantaneously and the operator may now set up the required number on the Digit Keys.

Interrupted Battery is fed through Cams A and B contacts N_2, M_2, H_2, T_2 and U_2 to the Driving Magnets of the Sender, the completion of the drive being effected by the operation of appropriate N, M, H, T and U Keys by the earth on the left-hand spring. Five keys on each strip are shown with the number 12345 set up.

When the operator depresses the Digit Keys, Battery is applied through the right-hand outer spring (which makes first) to the corresponding bank contact in the A arc of the Sender, the marking condensers being charged at the same time. Earth is applied at the left-hand outer spring of the keys to give the first step to the Sender Switches. The drive circuit of the N digit switch, for example, is from Interrupted Battery through N_2 Contact, Driving Magnet D, wiper normal contact L_1, contact N digit key to earth. After the first step the drive is completed to earth *via* the D arc and the MA Relay. The drive circuits for the other switches are similar.

The wipers will continue to drive until the marked contacts are reached when the marking condensers will discharge through the N, M, H, T and U Relays, the circuits of these Relays having been prepared by the closing of Contacts LA_1 to LA_5.

(9) As each of the Relays N, M, H, T and U operates, a holding circuit for each is completed by N_1, M_1, H_1, T_1 and U_1 *via* CC_5 to earth, while N_2, M_2, H_2, T_2 and U_2 break the drive circuit and connect up the Driving Magnets with contacts on the A arc of the Sender Controller ready to send out the impulses in proper order.

It should be noted that the B wipers being off-normal, earth is only connected at this stage to the B arc of the N digit switch, and the M digit switch B wiper will only be earthed when the N wiper has reached normal. This arrangement ensures that the digits are sent out in proper sequence. Contacts N_3, M_3, H_3, T_3 and U_3 will all be closed when the complete number has been set up; Relay S will then be operated and the Sender can now commence to send out the digits.

(10) *When S operates.*

S_1 disconnects the Sender in use from the Assigner which will step to the next free Sender. That is, the Assigner will not connect another Sender to the Operator until she has sent in all the digits to the Sender already taken. S_1 also completes the drive circuit of the Sender Controller.

S_2 releases Relays L and LA and provides a holding circuit for S *via* FR_2 and CC_3. The release of L and LA frees the keys for use on another Sender.

S_3 changes over but does not release the RS Relay which is now maintained *via* RS_2 and the Q_5 contacts. This Relay, which is associated with the cancel-out function, will, however, release immediately a Q Relay is operated, as it indicates that the operator has finished with the particular call on which it was operated.

With the release of Relays L and LA the Digit Keys will not affect the Sender in use and the keys can now be used on another call on one of the other Senders.

(11) When S_1 changed over, the Drive circuit of the Controller was completed from Interrupted Battery, Driving Magnet, V_1 D arm, C arc and wiper of Tens Digit Switch (which is off normal) Routine Test Key and S_1 to earth.

The Controller is stepped at 10 Impulses per second until the 7th contact is reached. This contact on the C arc is connected to the B arc of the N digit switch, which is earthed through its wiper. The circuit of the Relay A, which is connected to the C wiper, will therefore be completed when this contact is reached.

The interrupted battery feeding to Relay A lags behind the interrupter driving the Controller so that the C wiper will reach the 7th contact before battery is applied to A and a cut impulse is avoided. Relay A operates, and

A_1 opens the impulse circuit to the Selectors.

A_2 changes over and operates Relay V, which is a slow release Relay and holds during impulsing.

V_1 breaks the Controller Drive circuit.

V_2 prepares the circuit of the N digit switch magnet *via* the 7th contact on the A arc.

Interrupted Battery is supplied through Relay A, the C wiper and the 7th contact on the C arc to earth at the B arc in the Sender, and the A relay will therefore impulse.

Contact A_1 impulsing will cause the Selector Switches to rise while A_2 applies battery during each break period through V_2 and the A wiper and arc, N_2 and Driving Magnet of the Sender to earth *via* the MA Relay. The Sender N Switch will step in unison with the A_2 contact and this will continue until the normal contact is reached, when the circuit of Relay A will remain broken at the B wiper in the Sender. Relay V will release and its contacts return to normal. (The number of steps taken by the Switch in returning to normal corresponds with the number set up by the operator).

With the closing of V_1 the Controller drive is again completed and the Controller rotates until the C wiper reaches Contact No. 3, where earth is connected *via* the B arc and wiper of the M digit switch, normal contact and B wiper of the N digit switch. Relay A will again be operated and the thousands (M) digits will be sent out in the same way as the ten thousands (N) digits.

The contacts in the Controller associated with the five digit switches are:—
N—7: M—3: H—10: T—6: U—2, so that the Controller takes 7 steps between each digit, making a pause period of approximately 700 milli-seconds, plus the period of release of the V relay to allow switches to hunt for disengaged outlets. In the earlier part of the paper I have taken the release period of the V Relay as 150

milli-seconds, giving a total pause period of 850 milli-seconds between each set of digits. The Rotary Drive on ordinary Selectors is at 35 Impulses per second and 10/35th of a second or 286 milli-seconds is required to test over all outlets.

(12) The same procedure follows for the Hundreds and Tens digits; but if the A operator has failed to pick up the assigned Junction by the time that the Tens digits have been transmitted, the Controller drive circuit will be broken at the C arm of the Tens digit switch, which will be at normal.

As already described in (7) the A operator energises the Relay LR in the Junction and LR_1 short-circuits the 4000^{ω} spool in the B wire circuit of the Junction Seeker. Until this occurs, Relay P will not be operated, and with the return of the Tens Digit C arm to normal the circuit of Relay LF is completed and LF_1 changes over and gives slow lamp flash on the Sender Engaged Lamp.

Immediately the A operator takes up the Junction, Relay P will be operated and P_1 will change over, causing LF to release and the Sender Lamp to glow steadily. At the same time, the Controller drive circuit is completed *via* P_1 and normal contact of C arc to earth at S_1 and the Units Digits are transmitted in the same manner as described for the other digits.

If the A operator fails to pick up the Junction within a stated time, the B operator releases the Sender and Switches by pressing the "Sender Release Key."

(13) When the Units impulses have been transmitted, all the digit switches will be at normal and the Controller will be standing on Contact 2. The V Relay will release with the release of A, and V_1 completes the drive circuit *via* the D arc of the Controller. When the 10th contact is reached a circuit will be completed for Relay FR *via* CC_6 B arc and wiper to earth *via* the B wipers of the Sender in series and relay FR operates.

FR_1 releases Relays C and DF.

FR_2 opens the alternative earth provided for holding S.

FR_3 opens to prevent RS again operating with the release of S.

(14) *With the release of DF,*

DF_1 opens the holding earth.

DF_2 disconnects the Impulse wire from the Junction and establishes loop conditions towards the called subscriber.

DF_3 changes over but still holds N *via* LR_1.

DF_4 disconnects the Interrupted earth from the Supervisory Lamp circuit.

DF_5 opens and releases the R and P Relays.

When Relay R releases R_1 and R_2 return to normal, but Relay N holds as long as the A operator keeps a plug in the outgoing Junction Jack. The Junction is therefore now clear of the Sender and is under the control of the A operator entirely.

The release of P restores normal conditions for holding up the last digit on the next call passed into that Sender.

(15) Relay C was released by the operation of Relay FR. In turn, Relay C releases Relay CC and the closing of C_4 completes the drive circuit of the Junction Seeker which returns to normal and stands on its normal Contact. With the opening of CC_5, Relays N, M, H, T and U will be released. These Relays in releasing open the circuit of Relay S and with the restoration of the S Contacts normal conditions are restored to the Sender.

(16) Special arrangements can be made to send four, three and two digit calls by suppressing one, two or three digits by strapping out the particular N, NM, or NMH contacts in the S relay circuit, in which case the digit keys must be depressed in a specific order if five digit calls are also to be made.

Suppression of the last four digits can also be arranged for by making special wiring arrangements to complete the S Relay circuit through the bank Contacts on the C arcs of the digit switches.

(17) Reference has already been made to the functions of the Sender Disconnect Key; Sender Release Key; Cancel Key and Reassignment Key. The details of the operations are as follows:—

The Sender Disconnect Key opens the circuit of the AP and AQ Relays in the Assigner which will step to the next free Sender.

The Sender Release Key operates the FR Relay, thus bringing into operation the ordinary release functions.

These Keys are associated always with a particular Sender.

The Cancel Key, after the operation of Relay RS, is in the circuit of Relay CC and if operated; CC will release and CC_5 will release the N, M, H, T and U Relays, thus restoring normal conditions on the Digit Switches and the Sender with the consequent release of Relay S. A second Contact of this Key operates the Z Relays to discharge the condensers, thus clearing the contacts of the digit switches; but the Junction remains linked with the Sender, as Relay C is still operated.

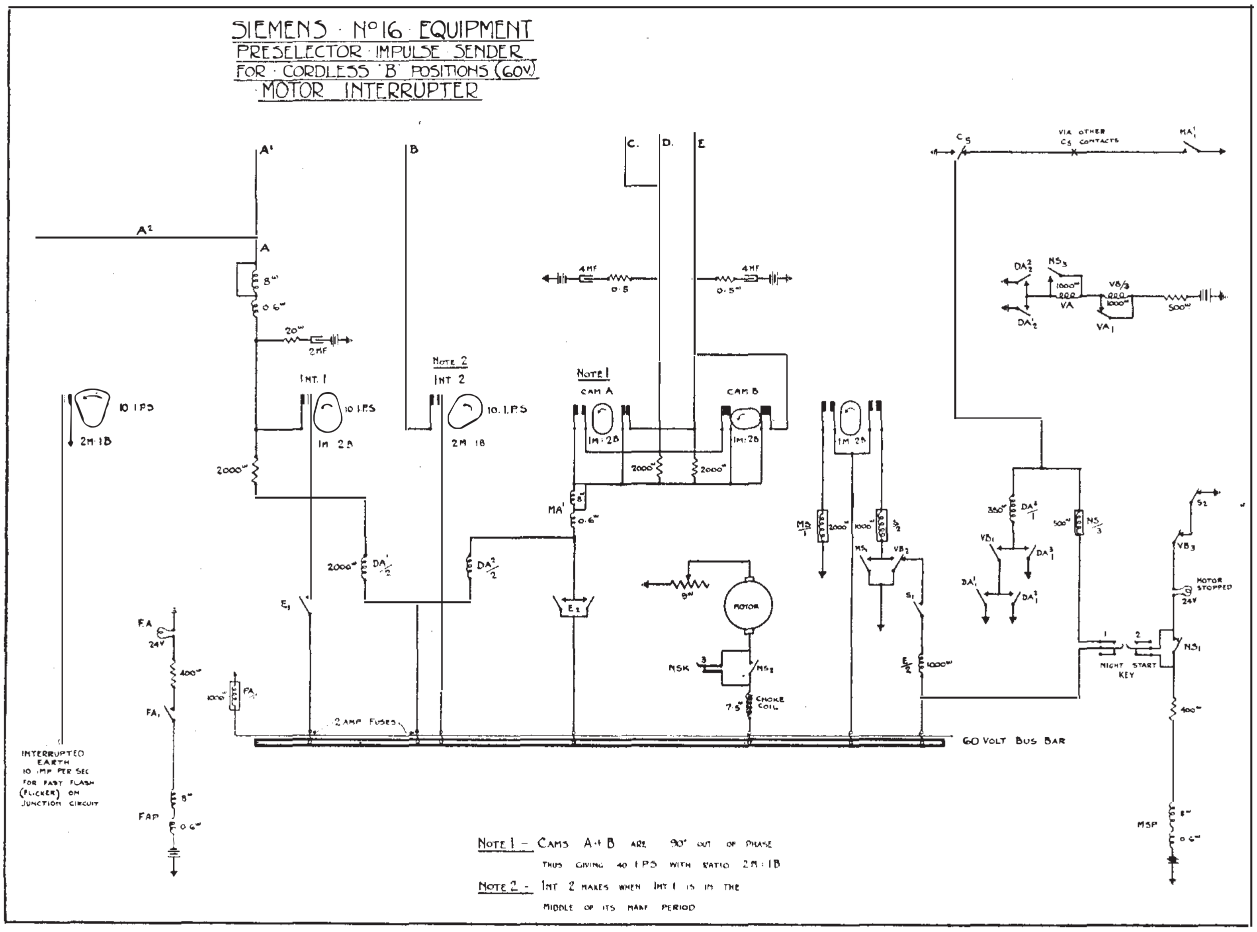

SIEMENS · Nº 16 · EQUIPMENT
PRESELECTOR · IMPULSE · SENDER
FOR · CORDLESS 'B' POSITIONS (60V.)
· MOTOR INTERRUPTER
A¹
A²
A
B
C.
D.
E
INT. 1
INT 2
NOTE 2
NOTE 1
CAM A
CAM B
10 I.P.S
2M 1B
MA¹
DA¹/2
DA²/2
E₁
E₂
MOTOR
NSK
NS₂
CHOKE COIL
MS
NS₁
VB₂
S₁
DA¹
DA¹/1
DA³/1
VB₁
NS/3
NS₃
VA
VA₁
VB/3
C5
VIA OTHER C5 CONTACTS
S₂
VB₃
MOTOR STOPPED
24V
NIGHT START KEY
MSP
F.A
FA₁
FAP
2 AMP FUSES
60 VOLT BUS BAR
INTERRUPTED EARTH 10 IMP PER SEC FOR FAST FLASH (FLICKER) ON JUNCTION CIRCUIT
NOTE 1 – CAMS A+B ARE 90° OUT OF PHASE THUS GIVING 40 I.P.S WITH RATIO 2M : 1B
NOTE 2 – INT 2 MAKES WHEN INT 1 IS IN THE MIDDLE OF ITS MAKE PERIOD

FIG. 2.

Contact CC_2 opens the circuit of Relay R in the Junction Circuit, thus releasing the selectors.

The Reassignment Key operates the WO Relay and since RS is operated the opening of Contact WO_1 opens the circuit of the C Relay and the Sender is released.

These Keys are common to all the Senders; but are definitely linked with the Sender in use.

(18) *Motor Interrupter.*—For continuous running the Night Start Key is normal and the circuit of the Motor is completed *via* Contact No. 3.

With the first throw of the cams Relay MS is operated and MS_1 closes, thus preparing the circuit of Relay S. When the cam operates the right hand spring set Relay S will operate, and as both are slow release they will hold all the time the Motor is running.

S_1 operates Relay E while S_2 opens the Motor Stopped Alarm Circuit. If the Motor stops, Relay S will release and the Motor Stop Pilot Relay (MSP) will be operated and the Motor Stopped Lamp will glow.

With the operation of Relay E, Contacts E_1 and E_2 close to complete the battery feed to the Interrupter Spring Sets. Motor failure will release E, thus disconnecting the battery feed and avoiding the possible burning out of Spring Sets and Driving Magnets.

Night Starting.—In this case the Key is thrown and the Motor Circuit and Motor Stopped Alarm are dependent on the operation of Relay NS.

The closing of the Q_1 Contact in the Drive circuit of the Seeker completes a circuit for Relay DA^2.

With the operation of DA^2

DA^2_1 prepares a circuit for DA^3 in series with NS.

DA^2_2 operates VA (Battery 500ω VA^1 Relay VA DA^2_2 to earth).

With the operation of VA

VA_1 opens the short circuit across VB, allowing the latter to operate when VB operates VB_1 completes the circuit of Relays NS and DA^3.

VB_2 disconnects E against the operation of S before the Motor has reached its normal speed.

VB_3 breaks the Motor Stopped Alarm circuit.

The operation of DA^3_1 closes a locking earth for NS and DA^3 in series independent of VB_1.

When Relay NS operates,

NS_1 prepares the MSP circuit which will be held open until VB releases.

NS_2 starts the Motor.

NS_3 short circuits VA which releases slowly. With the release of VA Contact VA_1 will short circuit Relay VB which will also release slowly.

The normal operations now come into play, MS being operated and in turn operating S, which in turn operates E. If the Motor stops during the application of current or if it fails to start, Relay S will not be operated after the operations of VA and VB, and the Motor Stopped Lamp will glow and the MSP Relay will bring in the Main Audible Alarm.

When the Junction Sender Seeker finds the Junction assigned, Relay C in the Seeker will be operated and C_5 changes over and holds NS; but short-circuits DA^3, which will release. When the impulses have been sent out, Relay C is released and C_4 completed the Seeker drive circuit, thus operating the MA^1 Relay. MA^1_1 will therefore be operated and with the return of C_5 to normal, Relay NS will be held until the drive of the Sender Seeker has been completed, *i.e.*, when the Preselectors reach normal. Relay MA^1 will then be released and Relay NS will also release.

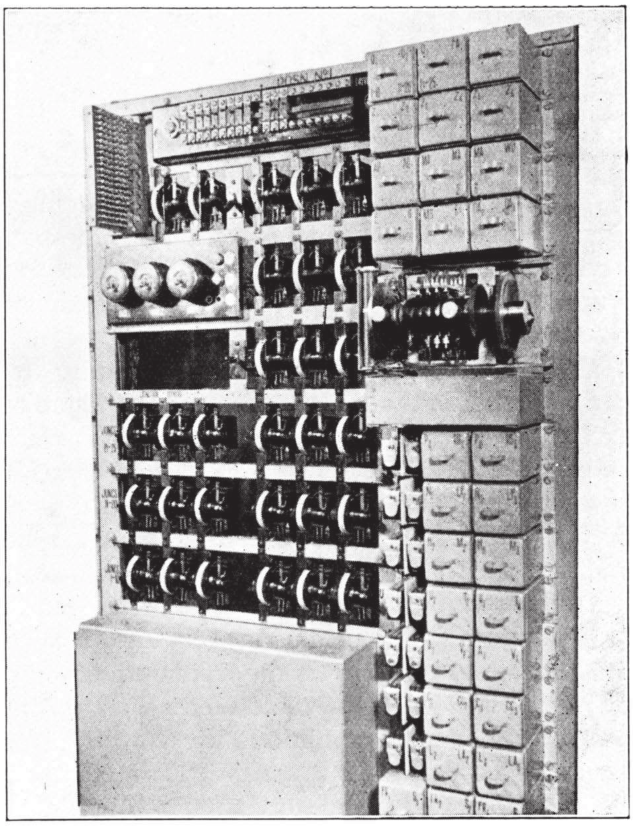


Fig. 3.—General view of Impulse Sender and Relay Assembly.

In this case the Motor Stopped Alarm will not be given, as it is stopped purposely.

Magnet Alarm.—On each operation of a Magnet a Relay MA will be operated. If this operation be prolonged, an alarm is given.

The diagram of the SA and ZA Relays and slow acting Cam used for bringing this Alarm into operation is not shown, as the arrangement applies generally to the Siemens No. 16 System and is not particular to the Impulse Sender.

The duration of the slow alarm is $\frac{5}{8}$ to $1\frac{1}{4}$ minutes.

Fuse Alarm.—This is the standard alarm circuit and need not be described in detail.

Routine Testing.—Provision is made for a Maintenance Officer observing the action of the Preselectors in sending out digits. The Routine Test Key is provided in the Drive Circuit of the Controller so that no digits can be sent out if the Key is operated. The Maintenance Officer may release the digits as soon as he is ready to observe the operation of the Preselectors.

AUTOMATIC EXCHANGE DEVELOPMENT.

DISCRIMINATING SELECTORS FOR SATELLITE EXCHANGES IN NON-DIRECTOR AREAS.

By J. HEDLEY, M.I.E.E.

UP to the present each telephone contractor has developed and installed Switching Selector Repeater equipment, or repeaters having access to discriminating selectors, at Satellite exchanges for working to the main or parent exchange provided by them.

The most economical method of affording the various conditions which are required at Satellite exchanges have been the subject of close study and investigation by Post Office Engineers for some considerable time, and a scheme has now been evolved, which it is proposed shall be manufactured, and installed by every contractor.

The underlying principle followed has been to incorporate features of existing circuits in such a manner that not only is the minimum amount of plant provided at the Satellite exchange, but well known circuit conditions are employed as far as is economically possible, thus enabling the equipment at Satellite exchanges to be as simple as possible, which will be advantageous from a staff training standpoint.

The method adopted in the standard group selector is employed by means of the 5 relays, A, B, C, G and H for impulsing, engaging and testing, and the usual mechanical functions of a step by step switch by means of the vertical rotary and release magnets.

Except for one or two contacts inserted owing to the need for discrimination the action of the discriminating selector switch is identical with that of a standard group selector.

The selector is provided with a 4th bank, and a 4th wiper. The additional contacts on the 10 levels of the extra bank are utilised to operate discriminating relays to enable the following facilities to be provided:—

(*a*) The first local digit to be absorbed, by restoring the switch to normal.
(*b*) The first and second local digits to be absorbed by restoring the switch to normal.
(*c*) Direct routing to an adjacent Automatic Exchange.
(*d*) Direct routing to the Manual board on "0" level calls.
(*e*) The junction to the main Exchange to be disconnected for conditions (*a*) (*b*) (*c*) and (*d*).
(*f*) The magnet circuits of the discriminating selector to be disconnected for all junction calls *via* the main Exchange.

The circuit arrangements are shown in (1).

The operation is as follows:—

(1) A operates over subscribers' loop.

(2) B is energised *via* A to place earth on private to engage the selector to other calling subscribers.

(3) Junction finder now rotates, and when an idle junction to parent exchange is found, K operates,. joining the Selector through to the parent Exchange, from which point the calling Subscriber receives the dialling tone. The earth from contact B is also extended *via* K contacts to the private of the selected junction, to engage it against other calling subscribers.

(4) MD is energised *via* contacts of B, and is retained *via* its own contacts. The relay provides an alternative earth on the private for "0" level calls *via* the manual board so pro-

viding the required operator hold facility on such calls; it also keeps the metering circuit open until the called subscriber replies.

LOCAL CALLS COMPLETED DIRECT FROM SATELLITE.

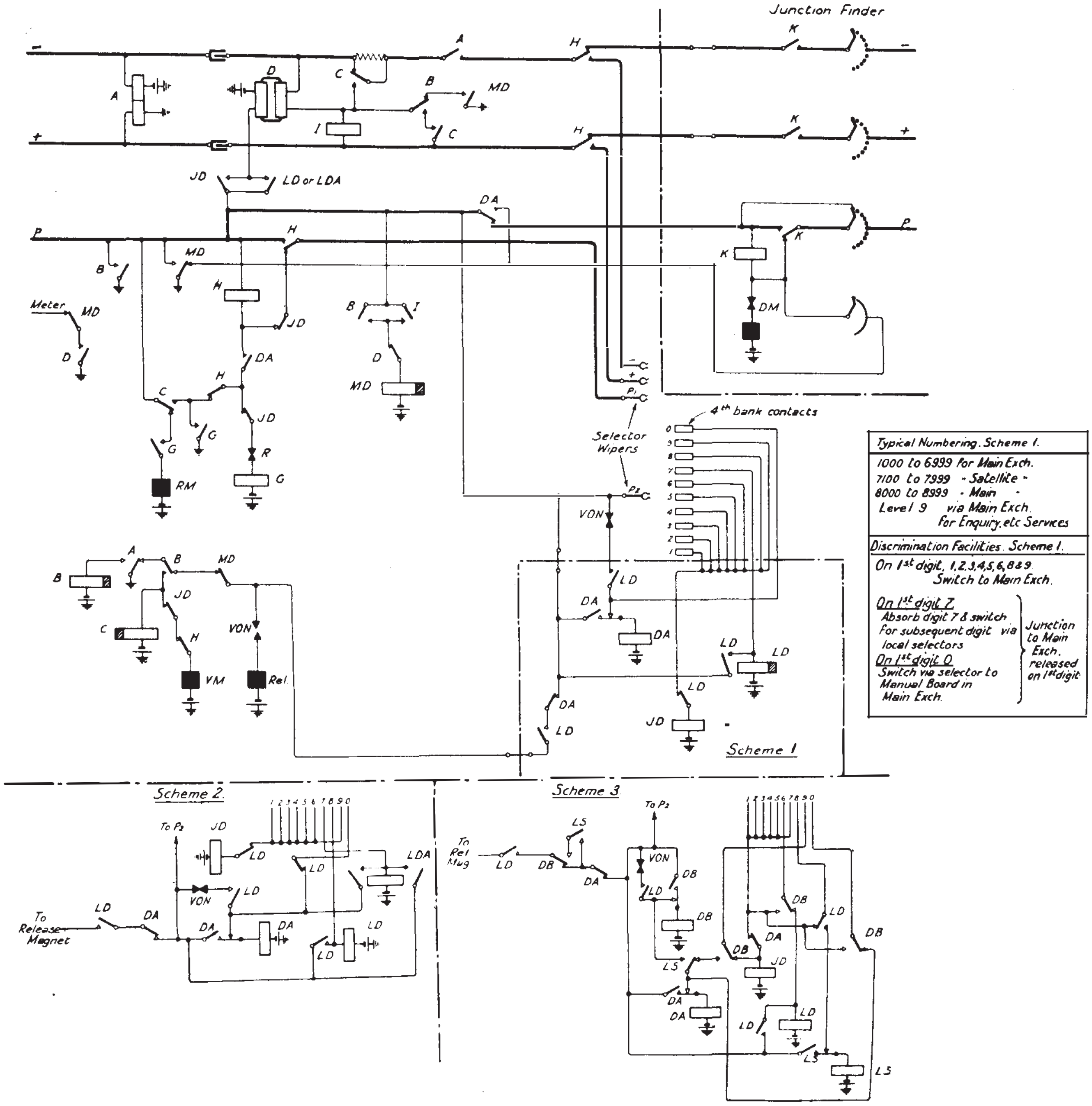
(5) For discriminating Scheme 1.

Subscriber dials the first local digit 8; the vertical magnet VM and C are energised in parallel. The Switch at the parent Exchange is also operated *via* contacts of A, C and B.

(6) G operates *via* C and B, and when C releases at the cessation of dialling, RM makes one rotary step, disconnecting G, and connecting wiper P2 with the discriminating bank of the selector on level 8.

(7) LD operates *via* wiper P2 and contacts of B and locks, *via* its own contacts. The release magnet is energised *via* contacts of VON, LD and B, causing the switch to restore to normal.

(8) DA now operates *via* LD and B and



SATELLITE EXCHANGE. NON-DIRECTOR AREAS. DISCRIMINATING SELECTOR.

locks *via* its own contacts, disconnecting K, releasing junction to the parent Exchanges and restoring the junction finder to normal.

(9) Subscriber dials second local digit, say, " 82." VM and C again operate in parallel to step the switch to the required level and as wiper P2 is now disconnected, relays G and H function in the normal manner to test and connect with the trunk outgoing to the Final Selector.

(10) The remaining 2 digits operate the Final Selector in the usual manner, and when the called subscriber replies D is energised to release MD and meter the call over the 4th bank of the rotary line switch in a manner similar to that adopted in director areas.

" O " LEVEL CALLS VIA THE MANUAL BOARD FOR TRUNK AND TOLL TRAFFIC.

(11) After operations 1 to 6 are completed, in this case to level " 0 " instead of level 8, DA operates *via* wiper P2 and contacts of B and locks *via* its contacts, disconnecting K, releasing the junction to the parent Exchange and restoring the junction finder to normal.

(12) The circuit of G and H is also completed *via* DA and these relays function in the normal manner to test for and connect with an idle junction direct from the bank contacts of level " 0 " to the manual board associated with the parent Exchange.

(13) Battery is connected to the line relay at the manual Exchange *via* the loop of I and D; the line relay operates and signals the operator; when the latter answers, the cut-off relay is energised to disconnect the line relay.

(14) Battery is now received direct from the Manual Exchange Cord Circuit on the positive line to energise I, but not D; the operator is able to hold the connection after the calling subscriber has restored his receiver *via* I, contacts B and MD.

NON FEE JUNCTION CALLS VIA THE PARENT EXCHANGE.

(15) For discriminating scheme 1 after operations 1 to 6 are completed, in this case for any level except " 8 " and " 0," JD operates *via* wiper P2 and contacts of B and remains energised until the calling subscriber restores his receiver.

The operation of JD disconnects the vertical and rotary magnet, relays G and H and the selector now functions as a repeater for transmission and metering purposes only.

NON FEE JUNCTION CALLS DIRECT FROM THE SATELLITE EXCHANGE.

(16) Discriminating scheme 1 does not provide for this service but for discriminating scheme 2. After operations 1 to 6 are completed, in this case *via* level 7 instead of 8, the call proceeds direct to the distant automatic exchange selector, the discriminating selector functioning as described under operations 11 and 12.

(17) For discriminating scheme 3, after operations 1 to 6 are completed, in this case *via* level 6 instead of 8, LD operates and the switch functions as for operation 7.

(18) DB now operates *via* LD and B and locks *via* its own contacts to prepare circuit for DA.

(19) Subscriber now dials 9 and DA is energised *via* wiper P2 and contacts of B and locks *via* its own contact and the switch functions as for operations 11 and 12 to connect with an idle junction *via* level 9 to the distant Automatic Exchange.

From the foregoing description of the circuit operations of Discriminating Scheme 1 and operations 15 to 18 for Schemes 2 and 3, the general principles for the remaining services available under Schemes 2 and 3 will no doubt be apparent. It will also be evident that the actual wiring of the discriminating relays to the 4th bank of the selector switch and the number of relays required will vary according to the numbering scheme adopted for the area and whether or not direct trunking to an adjacent automatic exchange from the Satellite Exchange is required.

The outstanding advantages of the Discriminating Selector, as now developed, are:—

1. Improved delayed metering conditions over 4th wire, enabling booster metering battery to be dispensed with.
2. Direct routing to adjacent automatic exchanges when required, instead of trunking all non-fee junction calls *via* the parent exchange, thus enabling economy on line plant to be effected.
3. Auxiliary relay equipment at the Satellite Exchange for calls to the manual board *via* level

"o" is dispensed with—thus improving transmission conditions on originating toll or trunk traffic.

4. Simpler circuit arrangements: the functions of the relays A, B, C, G and H and the vertical and rotary magnet correspond to those for impulsing and testing on group selectors, relays D, I, and MD to those on the 1st Code Selectors, for registration, manual supervisory and holding conditions. leaving only the group of discriminating relays 3, 4, or 5 to be wired for the particular numbering scheme and routing conditions of the Exchange concerned.

5. Scope for competitive tenders widened, as the P.O. Discriminating Selector can be manufactured by any Contractor and is suitable for operation with any Contractor's system existing at the main or parent exchange.

AN OUTLINE OF THE TRUNKING ASPECT OF AUTOMATIC TELEPHONY.

[*Abstracted from a Paper read by* Mr. G. F. O'Dell, B.Sc., *before the Institution of Electrical Engineers and published with the permission of the Institution.*]

As defined in the Post Office, the "grade of service" is the proportion of calls which fail to mature on account of shortage of switching plant. The grade of service has been defined in other ways by various investigators, but in the author's opinion the definition just given is simplest in conception and easiest to measure.

The settlement of a standard grade of service must clearly be based on a compromise between the desire to give subscribers as good a service as possible and the equally important desire to render that service as cheaply as possible. In the Post Office the standard has been fixed at 1 lost call in 500 at each switching stage, with the proviso that if the traffic increases temporarily by 10 per cent. the service shall not deteriorate below 1 in 100. The latter proviso is to allow for the well known fact that a large group of switches cannot stand an overload so easily as a small group, and it is desired that, in the event of a sudden increase of traffic of a temporary nature, the service shall not unduly deteriorate. In the special case of small groups of external junctions, which are often very expensive to provide, a rather lower grade of service than the standard is allowed.

The development of trunking may conveniently be considered under two aspects—the quantitative, which is concerned with the amount of switching plant required to handle a given amount of traffic, and the qualitative, which relates to the methods adopted for arranging switching plant to the best advantage. In recent years a considerable literature on the former has grown up, and it can only here be stated that the theory associated with the name of Erlang is considered most nearly to represent conditions obtaining in the Post Office. On the qualitative side there has been considerable development, and the central link frame of Messrs. Siemens Bros. (described in "Siemens No. 16 Automatic Equipment," by C. W. Brown, Institution of Post Office Electrical Engineers, Professional Paper No. 100) and the link frame terminal assembly of the Automatic Telephone Manufacturing Co. (now being introduced into Post Office exchanges) represent the latest phase.

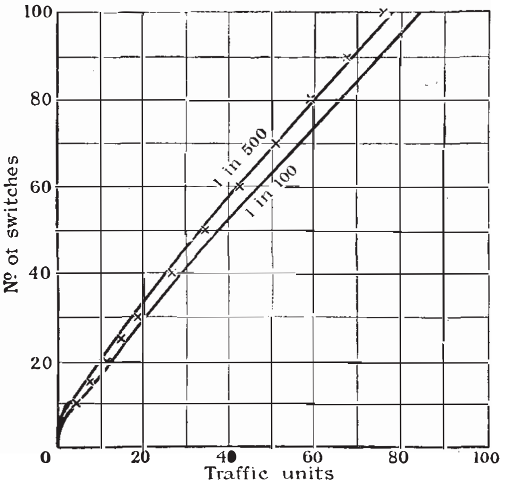


Fig. 1.—Traffic Capacity of Switch Groups.

Erlang's curves have been published many times, but it may be of interest to consider the effect of the two-fold grade of service adopted by the Post Office.

TABLE I.

TRAFFIC CAPACITY OF SWITCHES (ERLANG'S THEORY).

(Grades of service of 1 in 500, 1 in 100, and also 1 in 100 calculated on 10 per cent. increase of traffic.)

Number of switches.	Traffic capacity for grade of service of		
	1 in 500.	1 in 100	1 in 100 on 1.1 traffic.
1	0.002	0.01	0.009
2	0.065	0.153	0.139
3	0.25	0.455	0.414
4	0.53	0.870	0.791
5	0.90	1.36	1.24
10	3.43	4.46	4.05
15	6.58	8.11	7.37
20	10.07	12.03	10.9
24	13.01	15.3	13.8
25	13.76	16.1	14.6
30	17.7	20.4	18.5
40	25.7	29.0	26.4
50	33.9	37.9	34.5
60	42.4	46.9	42.6
70	51.0	56.1	51.0
80	59.7	65.3	59.4
90	68.5	74.7	67.8
100	77.4	84.1	76.4

Table I. gives in cols. 2 and 3 the amount of traffic carried by groups of the sizes given in col. 1 for grades of service of 1 in 500 and 1 in 100 respectively. In the last column the values of traffic are 10/11 of those in col. 3, *i.e.*, the traffic in col. 4 is the traffic which, if increased by 10 per cent., will give a grade of service of 1 in 100 with the size of group given in col. 1. To conform with both parts of the standard grade of service, then, the traffic chosen for any size of group must be the smaller of the two values given in cols. 2 and 4. These values are the same for a group of 70 switches. For smaller groups the grade of service of 1 in 500 is more severe than the grade of service 1 in 100 reckoned on 10 per cent. increase of traffic; for larger groups than 70 the reverse holds. These results, which of course apply only to the "full availability" case, are illustrated in Fig. **1**; the curves are for grades of 1 in 500 and 1 in 100 respectively, while the figures in col. 4 of Table I. are shown, for clearness, as crosses.

Those familiar with the design and construction of automatic switching plant will realise that the "full availability" conditions do not occupy a very large place in practice. Taking the exchanges now being installed in London as an example, each subscriber's pre-selector has a bank of 24 contacts and therefore has access to a maximum of 24 1st selectors; in other words, the "availability" of 1st selectors is limited to 24 on account of the design of the pre-selectors. In any exchange where the number of 1st selectors exceeds 24, therefore, full availability conditions do not obtain, and the "availability" is said to be "limited." Similarly group selectors having 10 contacts per bank level limit the availability of succeeding switches to 10, and the more recent group selectors having 20 contacts in the bank level similarly limit the availability to 20.

When the availability is limited, the question arises of how best to join the banks of the switches of one rank to the wipers of the next. In most of the earlier exchanges, both in this country and in America, the switches of one rank were divided into groups each containing a number equal to or at any rate not greater than the number of contacts in the banks of the preceding switches.

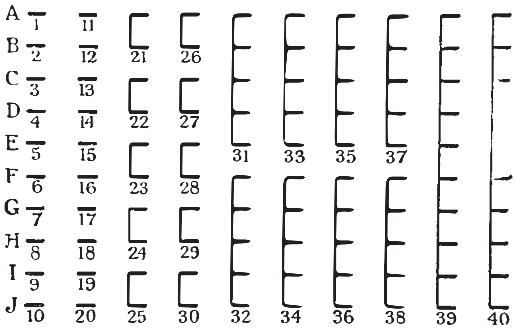


FIG. **2**.—DIAGRAM ILLUSTRATING PRINCIPLE OF GRADING.

This arrangement—besides being uneconomical—is very inflexible. An examination into other methods of trunking is too long to be reproduced here. Suffice it to say that the method of grading has now been adopted by the Post Office. The principle of grading is illustrated in Fig. **2**. A detailed study of the traffic capacity of gradings leads to the information shown in Fig. **3**, which shows the traffic capacity of 10-contact gradings with various numbers of groups.

From a study of these curves it will be deduced that 2-group gradings are satisfactory if the number of outlets required does not exceed 15, 4-group gradings are satisfactory if the number of outlets required does not exceed 25, and 10-group gradings if the number does not exceed 50. It will be noticed that the latter number is just one-half the maximum possible number of outlets from the grading, namely, 100. Speaking generally it may be said that no grading should be used, if it can be avoided, in which the actual number of circuits required to the next rank of switches exceeds half the maximum possible number. An 18-group grading, for example, should not be used when more than 90 circuits are required. This rule may be departed from in the following cases where the number of groups is small; thus 2-group gradings may be used for a maximum of 15 outlets, 4-group gradings for a maximum of 25, and 6-group gradings for a maximum of 32 outlets. If the rule be departed from in other cases, a loss in traffic capacity will occur and the tables and curves given later will not apply. These specific data are, of course, with reference only to the gradings of 10-contact switches.

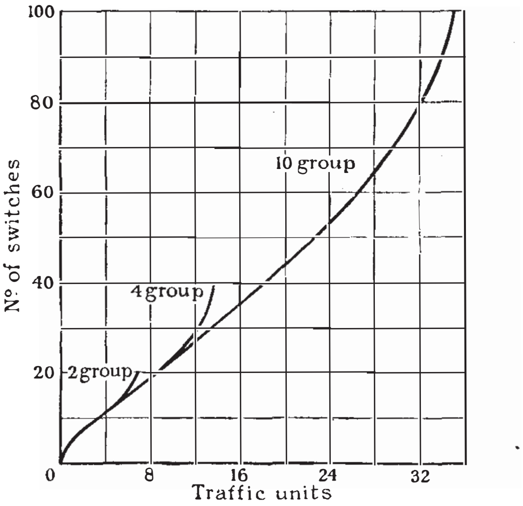


FIG. 3.—TRAFFIC CAPACITY OF GRADINGS.

A study of Fig. **3** will show that the curves are very approximately straight from 10 switches until the point of maximum traffic capacity is reached, and that they lie very approximately on the same line. Similarly, in Fig. **4**, it will be seen that the value of the average traffic capacity per switch is tending towards a constant value, so that there is no great advantage in very large gradings.

Summarising, the best effect from a grading of the type described is only obtained if, first, the grading is "smooth," and, second, the number of groups is so chosen that the number of outlets does not exceed half the maximum possible number. In practice, the number of groups to be adopted for any given case will depend on other factors; it should always, if possible, be at least equal to the value found as above.

Another factor which has to be taken into account is the "distribution" of traffic.

In all the foregoing it is assumed that we are dealing with pure chance traffic. Where this is not the case other considerations must enter. But first it will be asked—"What is pure chance traffic?" A first reply, which will be investigated in slightly more detail, is that pure chance traffic is traffic occurring when a call is as likely to originate at any one instant as at any other during the period under consideration. Such a condition can only apply to a small portion of the day—usually considered to be the busy hour—and even then is liable to be upset by various incidental circumstances. If, for instance, a subscriber makes two calls in the busy hour, these calls cannot be in progress simultaneously. In other words, the time at which the second call originates is governed to some extent by the first. Again, a fire or breakdown of power supply will cause many calls which would not otherwise have been made, and the tendency is for such calls to be simultaneous. But the effect of the conditions mentioned is comparatively small, and tests have shown, very approximately, that the calls originated by subscribers during the busy hour are as likely to originate at any moment of that hour as at any other—in other words, the traffic is pure chance.

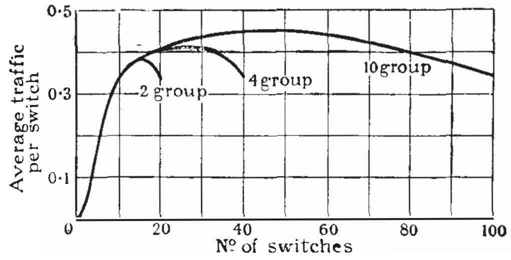


FIG. 4.—AVERAGE TRAFFIC PER SWITCH FOR VARIOUS GRADINGS.

But what happens to traffic within the exchange? Before a call can be connected to the required subscriber, whether in the same exchange or any other, it passes many switching points, and at each of those switching points the traffic undergoes some alteration.

Considered as a whole, of course, the traffic undergoes no change in distribution as it passes through the exchange. Except for the comparatively few calls which fail at some stage due to shortage of switching plant, to faults or to abandonment, all calls follow in the same sequence and at the same intervals. The sum total of calls on all 2nd selectors in a single junctionless exchange, for example, is the same as that on all 1st selectors, and the proportion of simultaneous calls of various numbers is the same at both stages if we consider the whole traffic. When outgoing and incoming junctions are taken into account, the actual calls at any one stage are not identical with those of other stages, but, broadly speaking, the distribution of traffic is not altered.

But when the various groupings of 1st selectors or of 2nd selectors are considered, then this equality of distribution need hold no longer. Assuming, for instance, that we have a volume of pure chance traffic and wish to distribute it among various groups of switches, we can imagine the distribution effected either by a chance method or by a definite selection. As an illustration, suppose that 1000 calls occurring within an hour and with an average duration of 3.6 minutes need to be divided among 10 groups; we can either in imagination draw counters for each call in order to determine which group shall take any given call or we can use our judgment and not leave the matter to chance. We might, for instance, say that calls shall take the various groups in definite relative order. In the latter case the number of calls in each group would be exactly 100; in the former it would average 100 but would vary from group to group. But, more important still, the proportion of time during which any given number of calls existed simultaneously would be very different in the two cases. The average traffic per group will be the same in each case, namely, 100 × 3.6 ÷ 60 = 6 traffic units. The difference in distribution can be illustrated by curves such as those in Fig. 5, which show the proportion of time during which exactly 0, 1, 2, etc., calls are in progress simultaneously for pure chance distribution in curve A, and for "selected" distribution in curve B.

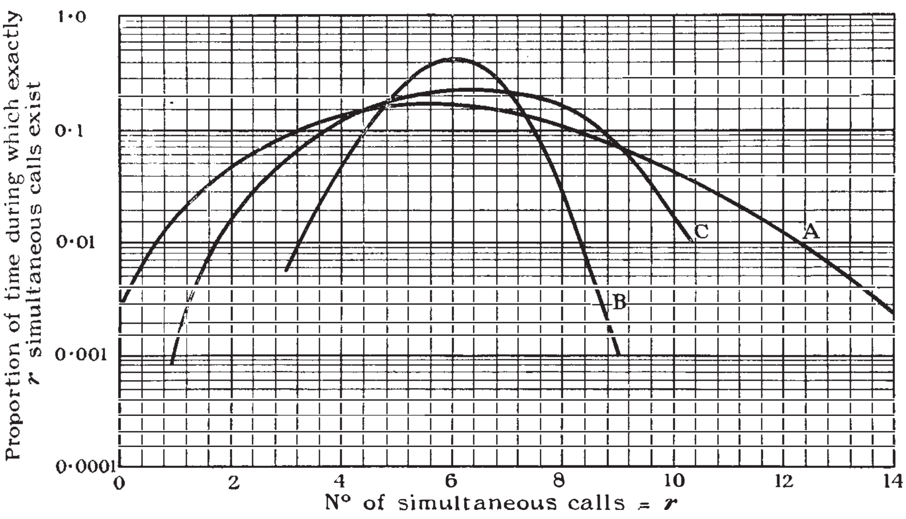


FIG. 5.—TRAFFIC DISTRIBUTION CURVES.

In the latter case the distribution is much smoother, and it is therefore to be expected that fewer switches would be required to carry it at subsequent stages than would be required for pure chance traffic. But, though we can imagine calls being distributed in this selective way, it is not possible actually to accomplish such selection in practice.

We can, however, exercise some discrimination by means of such a scheme as the well known 1st and 2nd pre-selector scheme used by Siemens Bros. and others. When the calls are scattered over 100 1st selectors in this way it is to be expected that the distribution of calls over any shelf is smoother than would be the case for pure chance traffic of the same volume. The effect is increased by the group control arrangement, which prevents calls from coming into any row of 20 2nd pre-selectors when all the outlets from this row to 1st selectors are engaged. As is well known, the arrangement is almost equivalent, so far as traffic capacity is concerned, to "full availability" over 100 1st selectors, because any call may reach any one of those 100 selectors. The distribution of 6 traffic units on one shelf of selectors in this case is shown in curve C of Fig. **5**.

Allowing for this effect between 1st and 2nd selectors, 6 principal design curves are now used by the Post Office. They are illustrated in Fig. **6**.

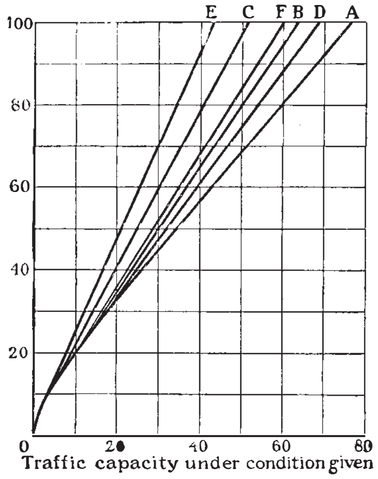


FIG. **6**.—TRAFFIC CAPACITY OF SWITCHES UNDER VARIOUS CONDITIONS. STANDARD GRADE OF SERVICE.

Traffic records are required for three purposes:—(1) In order to measure the grade of service given over various routes, (2) in order to measure the traffic passing over various routes and (3) for general statistical purposes.

It will be realized from what has gone before that for any grouping of switches the amount of traffic lost for any given volume and distribution of total traffic is exactly determinate. The same is true of the traffic carried by each individual switch in the grouping. Hence the traffic carried by any one of these switches may be used as a measure of the traffic carried by the whole, and also of the lost traffic. The relation between these three quantities is very involved and difficult to find, but, once determined, is available for all time. When the arrangement of a grading is considered, the most convenient switch for the measurement of traffic is seen to be the one connected to the last contact of the grading, because this is to some extent affected by the traffic on all the groups in the grading. As a measure of the total traffic carried by the grading, the number of traffic units (rather than the number of calls) carried by this last contact is required. This traffic is, however, very small and therefore one or two calls of abnormal duration might easily lead to wrong conclusions. The circuit is therefore designed to measure in addition the number of calls carried by the switch; the ratio of the two quantities is the average holding time of calls carried by this switch. Fig. **7** shows the actual circuit arrangement. The private wire of the last contact of the grading is connected to a meter, A, and battery; the meter is therefore operated once (by means of the earth which is then connected to the private contact) for each call carried by the switch connected to this last contact. In the local circuit of meter A is a second meter, B, the circuit of which includes contacts closed for a few seconds every half-minute. Such contacts are included in practically all automatic exchanges as they are required in connection with the exchange alarm scheme. Meter B therefore records the average number of times the switch concerned is engaged at half-minute intervals, that is, the reading of meter B divided by 120 is the traffic carried by the switch in traffic units. The ratio of the reading of meter B to that of meter A is the average duration in half-minutes of calls carried by the switch. One disadvantage of using the last-contact switch for traffic measurement is that it carries

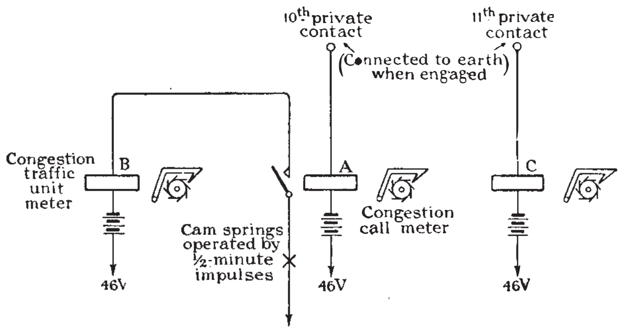

10th private contact
11th private contact
(Connected to earth when engaged)
Congestion traffic unit meter
B
A
C
Cam springs operated by ½-minute impulses
Congestion call meter
46V
46V
46V

FIG. **7**.—CONGESTION AND OVERFLOW METERING CIRCUITS.

a very small amount of traffic; the readings of the meters therefore vary considerably and must be continued for a long period before they give a reliable indication of the traffic on the whole grading.

Calls which fail to find a disengaged outlet are recorded on an overflow meter (meter C in Fig. **7**). Each shelf of selectors has an eleventh contact in the private bank on all levels, and this contact is multipled over the same shelves as the tenth. The overflow meter is connected to this contact and therefore records calls which fail to find an outlet in that particular grading.

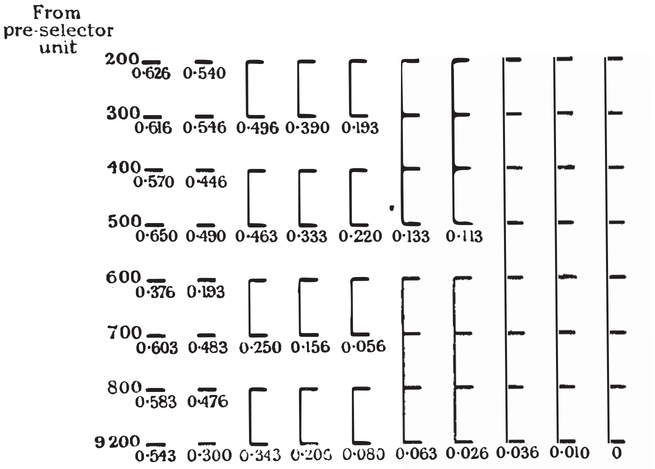


FIG. **8**.—TRAFFIC DISTRIBUTION CHART.

The figures against each Circuit show the average traffic carried by that Circuit. Total Circuits working = 35.

This meter remains operated as long as the calling subscriber remains on the line. Should a second call fail to find an outlet in the same grading, it will not be recorded. As is well known, the calling subscriber in both these cases will receive the busy signal. The error due to this "overlapping" of busy calls will be negligible as long as a good service is given.

Measurements of the traffic passing over various routes are based on the fact mentioned several times, that the traffic carried by any group of switches is equal to the average number of switches simultaneously engaged. This number can be determined quite easily in many cases by actual observation, the number of engaged switches being recorded at convenient intervals (usually ½ minute to 3 minutes) and the average found. This method has the advantage that the traffic carried by each switch can be determined if desired, and the distribution of traffic over the grading is then known. Though a large number of records have been taken by this means it is tedious, and an automatic method of counting the switches has been devised.

As an example of the results obtained by the manual method of measuring traffic, Fig. **8**, showing the traffic carried by each outlet in a grading from one level of 1st selectors at Official Exchange, may be of interest. As will be expected, the individual outlets carry most traffic. It will be seen that the total traffic carried by the group of circuits is 11.6 traffic units, as against 14.6 which the group may be expected to carry with the normal grade of service. Noticing further that the last contact carried no traffic during the period of observation, and remembering that the total number of calls in this period (10 hours) was approximately 4,000, it will be seen that the grade of service is exceedingly good. The record was taken shortly after a rearrangement, in which some allowance was made for growth of traffic; hence the exceptionally good grade of service.

Records taken by these means on all the groups in an exchange may conveniently be summarized on a traffic diagram such as that shown in Fig. **9**. This diagram bears the results of a traffic record taken at Ipswich during August and September, 1926. Each group was observed for a period of 2 busy hours per day for 5 days and the records for the busier hour for each of the 5 days were averaged. In order to economise staff the records were not taken all at one time, but were spread over a period of 4 weeks. On the diagram the traffic carried on each route is shown against the route. It will be found possible by this diagram to obtain a check between the traffic passing into a group of switches and the total traffic passing out over the various levels of these switches.

If desired, the theoretical traffic carried by each group may also be added to the diagram, to facilitate the detection of cases in which groups are either over-loaded or under-loaded. The conclusions deduced by these means should be compared with those reached from a study of the congestion and overflow meters.

There is a possibility of apparent contradiction between these conclusions on account of the distribution of traffic over the groups of a grading being uneven. This can be checked by means of diagrams such as Fig. **8**.

Successive diagrams of the kind shown in Fig. **9** render possible a watch on the growth of traffic.

Since the paper was read, a very interesting description by Dr. Maitland of the traffic recording scheme in use at Amsterdam has appeared in the *Post Office Electrical Engineers' Journal,* 1927, Vol. 20, No. 1, p. 22.

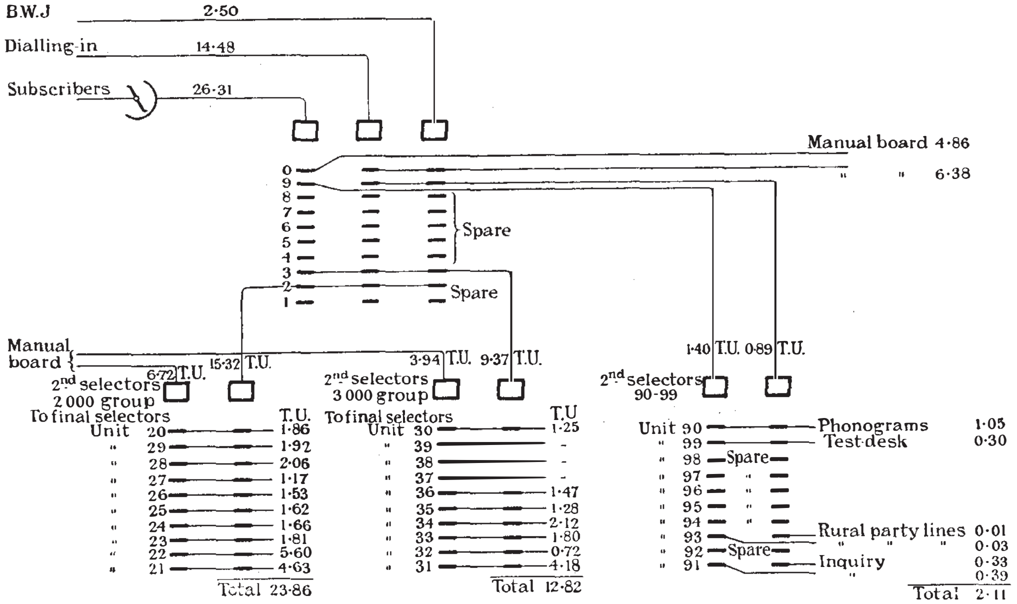


FIG. 9.—TRAFFIC DIAGRAM, IPSWICH.

SOME TESTS ON SOUND ABSORBING MATERIALS.

W. WEST, B.A., A.M.I.E.E.

1. INTRODUCTORY.

THE present article is a review of a brief investigation carried out at the Post Office Engineering Research Section Laboratories on a few materials of good absorbing power, and the conclusions arrived at, where general, are applicable to porous materials such as curtains, studio drapings, etc., wherein the pores are small and very numerous.

While in general the effect of a sound wave meeting an obstacle is divisible into Transmission through, Reflection from and Absorption by the obstacle, the actions involved may differ according to the nature of the obstacle. Thus the transmission of sound through a wall of paper is mainly due to diaphragm action, that is motion of the paper in response to the alternating air pressure, while if the wall is of muslin the transmission is mainly accounted for by penetration of the sound through the interstices of the fabric. This latter is the nature of the transmission through materials of the kind dealt with in this article.

2. APPARATUS.

The apparatus used for testing the materials comprised essentially a brass resonating tube, about 6 cms in diameter and 80 cms in length, into the centre of which was suspended a Rayleigh disc. A window was provided in the side of the tube to admit a beam of light reflected from the disc to a graduated scale on which readings were taken. The general arrangement is illustrated in Fig. **1**.

The tube was fitted with adjustable end pieces, one of which (A) communicated with a telephone receiver which supplied the sound energy required to maintain resonance. Tests were made by introducing samples of material at the other end (B).

The Rayleigh disc was about 0.8 cm in diameter, suspended normally at about 45° to the axis of the tube. Readings of the deflection of the spot of light on the graduated scale indicate the angular deflections of the disc which are proportional to the square of the air particle velocity at the cross section of the tube through the disc.

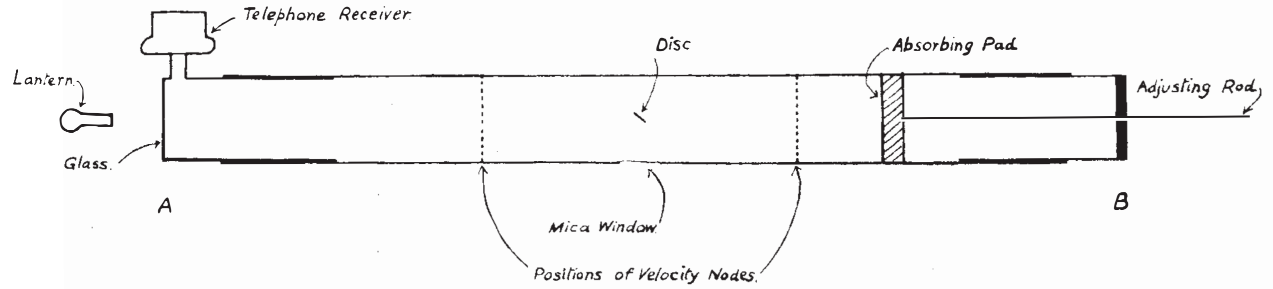


FIG. **1**.

When a closed tube is in resonance at a frequency whose wave-length is λ, its length is a multiple of λ/2 and nodes of velocity exist at the ends and at sections of the tube distant λ/2 apart, while loops of velocity exist midway between the nodes.

3. PRELIMINARY TEST.

For this test the apparatus was arranged as shown in Fig. **1**. The ends were 84 cms apart, the disc being midway between them. A frequency of 600 cycles per second was used (λ = 56 cms) and nodes of velocity existed in the positions shown in the figure. End B was closed except for a small aperture through which could be pushed a wire, used to vary the position of a pad of material (cotton waste, 1 inch thick) within the resonating tube. Readings were taken of the disc deflections for different positions of the pad, and these are plotted in Fig. **2**, Curve 1.

The curve shows that the strength of resonance was greatest when the pad was at a velocity node and least when at a loop, and that the variation was considerable. As a similar effect might be produced by reflection from the face of the pad, a further test was made. The closed end B was removed and replaced by a deep packing of loose cotton wool, so that, instead of resonance, the conditions approximate to those of a plane wave travelling along the tube and, for the most part, being absorbed at the end. Readings taken of disc deflection and position of the pad (Curve 2) show that the effect is small as compared with that in the previous test.

The inference is that the absorbing power of a layer of a material (thin as compared with a wave length) when introduced into a sound field of standing waves varies with the position of the material, being greatest at a velocity loop and least at a velocity node. This result is confirmed by a later test, described in the following section.

In cases where walls are covered by a thin layer of draping at their surfaces, for sounds of high frequencies the nearest velocity loop may lie within or near the draping, while for lower frequencies it will be situated farther off. This is one reason why, in a room of this type, a

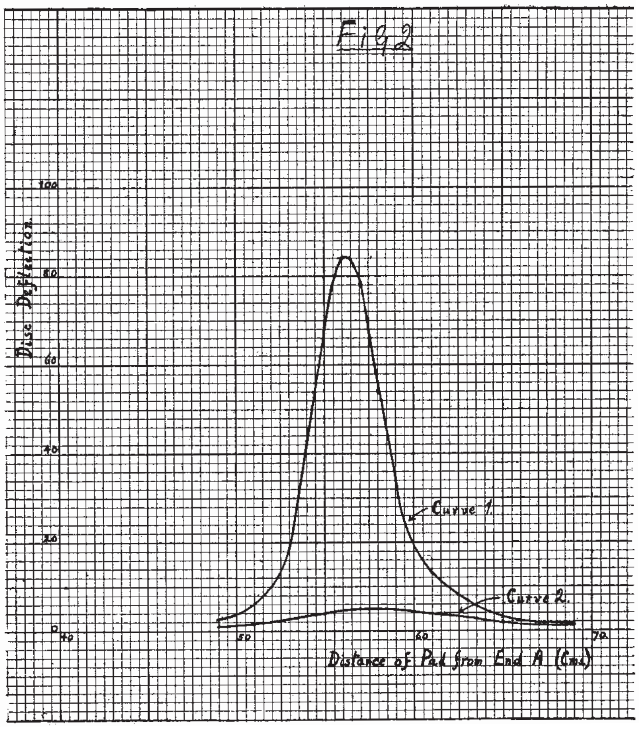


FIG. **2**.

larger proportion of sound is reflected at low frequencies than at high frequencies.

4. DECREMENT TESTS.

For this method of test the author is indebted to Professor E. Mallett of the City and Guilds College. Essentially the method consists in determining the decrement Δ_0 of a resonating column of air, then introducing a sample of material and finding the decrement Δ_1 with the added resistance due to the material. Since the decrement of a simple resonating system is proportional to the resistance (the other constants being unchanged) it follows that Δ $(= \Delta_1 - \Delta_0)$ is proportional to the frictional resistance due to the presence of the sample under test, and is therefore a measure of the absorbing power.

In order to determine the decrement, the electrical input to the receiver was maintained at a constant value while a number of readings were taken of the deflection of the disc for small changes in the length of the resonating tube near the correct length for resonance. A curve plotted in terms of tube length against disc deflection has the nature of a simple damped resonance curve, and the decrement may be obtained by means of Professor Mallett's graphical method.*

As shown by the previous test, it is important that each sample of material tested should occupy the same space and position in the tube for the results to be comparable. For these tests, the results of which are given in Table I., the sliding end at B was closed and filled with material, packed as far as possible to a uniform density, to a depth of 2 inches.

TABLE I.

f = 600 CYCLES PER SEC., λ = 56 CMS., Δ_0 = 0.4.

Sample number.	Material.	Mass Gms.	Δ $(=\Delta_1 - \Delta_0)$
1	Cotton Waste	10.5	0.9
2	Cotton Wool	2.5	1.5
3	Packing Felt	3.0	0.45
4	Towelling	8.8	2.0
5	Gamgee Tissue (4 layers to 2 ins.)	3.6	2.2
6	Gamgee Tissue (7 layers to 2 ins.)	6.3	2.8
7	Gamgee Tissue (9 layers to 2 ins.)	8.1	2.75

Samples 1-3 were taken from loose material, the remainder were cut, from sheets, into discs which were laid together to a depth of 2 inches. The cotton waste was not brushed and only partially purified. The gamgee tissue was a good quality surgical cotton wool laid in sheets between muslin.

An individual test was made with sample number 5 placed, instead of against the closed end B, at a distance of about $\lambda/4$ therefrom. This gave Δ = 5.3, a result which confirms that of the preceding section.

A test was also made with sample No. 5, replaced at B, at a higher frequency, namely, 1000 cycles per second, at which Δ was found to be 3.3.

5. RATIO TESTS.

Another method of test* was used for determining the absorption of an unlimited thickness of the material. (This method can be applied to find the percentages of sound reflected from and absorbed by any obstruction provided that the percentage transmitted is negligible. Thus it can be applied in the case of a thin layer of absorbent material backed by a rigid surface provided that the relative positions of the material and the wall are kept the same for the test, and that it is understood that the test applies to the material and the wall, in combination, in the particular relative positions under which the test is made.)

For these tests the sliding tube at B was replaced by one about a foot long, open at both ends and filled with the material under test. The test was carried out by sliding this tube in the main resonating tube and observing the disc deflection—which has alternate maximum and minimum values for positions $\lambda/4$ apart of the sliding tube. The ratio of the maximum to the minimum values was observed. In order to verify that sufficient material was being used to give the equivalence of unlimited depth, the far end of the filled tube was closed and opened, and it was observed that the disc deflections were unchanged.

Since in the test the conditions are those of a plane wave meeting the material, the reflected wave also being plane, the results, when referred to obstacles in the open, therefore apply only to surfaces with dimensions large as compared with λ.

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* *Journal I.E.E., Vol.* 62, *p.* 517, *June,* 1924.

* *Similar to that of H. O. Taylor, Physical Review, October,* 1913.

If d_1 be the maximum deflection observed and d_2 be the minimum, then, of the velocity of a single plane wave incident on the material, the fraction k which is reflected is given by

$$k = \frac{\sqrt{D} - 1}{\sqrt{D} + 1}, \text{ where } D^2 = \frac{d_1}{d_2}.$$

(A method for obtaining this equation is given in an appendix). The fraction k also applies to the ratios of pressure and of amplitude of the incident and reflected waves; the energy ratio is given by k^2. Since the percentage transmitted is zero, it follows that the fraction of the incident wave that is absorbed is given by $1 - k^2$ in terms of energy.

The results of tests are shown in Table II. for a frequency of 600 cycles per second, and in Table III. for observations, at a few different frequencies, on sample number 13.

TABLE II.

f = 600 CYCLES PER SECOND, λ = 56 CMS.

Sample Number.	Material.	Deflection Ratio (D^2)	Reflection factor (Amplitude) (k)	Absorption factor (Energy) ($1-k^2$)
8	Cotton Waste	7	·23	·945
9	Cotton Wool	5	·2	·96
10	Loose Packing Felt	5	·2	·96
11	Towelling	12	·3	·91
12	Gamgee Tissue (Moderately Compressed) ...	8.5	·25	·93
13	,, ,, (,, Loose)	6	·22	·95
14	,, ,, (Loose)	4	·17	·97

TABLE III.

TESTS ON SAMPLE NUMBER 13.

Frequency f	Wave-Length λ	Deflection Ratio (D^2)	Reflection factor (Amplitude) (k)	Absorption factor (Energy ($1-k^2$)
600	56.0	6	·22	·95
995	54·2	4	·17	·97
1377	24·7	3	·14	·98

6. COMPARISON OF THE METHODS.

The results so far obtained by these two methods are not comparable, since in the decrement test the material was limited to a thickness of two inches, placed against a rigid surface, while in the ratio test the thickness of the material was, for practical purposes, unlimited. Even were this not the case, although both methods of test would give the same relative indication of the absorption qualities of different samples of materials, the numerical results would not be directly comparable. It is therefore of interest to notice the relationship between the decrement figures of different samples (tested under the same conditions) and the absorption or reflection factors of similar samples.

When the tube is adjusted to resonance, the maximum velocity, as measured by the Rayleigh Disc, is inversely proportional to the frictional resistance, that is, to the decrement. This velocity is also proportional to $\left(\frac{1 + k}{1 - k}\right)$ (see Appendix), whence $\frac{\Delta(1 + k)}{(1 - k)}$ is a constant for different materials or arrangements of material.

The ratio test was applied to a few of the samples whose decrement figures had previously been determined (Table I.), and the results are given below in Table IV. It will be seen that the values of $\frac{\Delta (1 + k)}{(1 - k)}$ given in the last column are the same—within limits allowable for experimental error.

TABLE IV.

f = 600 CYCLES PER SEC., λ = 56 CMS.

Sample Number. (See Table I.)	Deflection Ratio (D^2)	Reflection factor (k)	Decrement Δ (Table I.).	$\frac{\Delta (1+k)}{(1-k)}$
2	240	.60	1.5	6.0
4	90	·51	2.0	6.2
5	60	·47	2.2	6.1
6	27·5	·39	2.8	6.4

7. GENERAL COMMENT.

Considerations affecting the sound absorption properties of materials are dealt with in § 351, Vol. II. of Lord Rayleigh's "Theory of Sound," wherein the case of a continuous wall perforated by a number of similar narrow channels is considered in detail. The nature of absorption by these means is similar to that by the materials which have been tested, but the conditions are not exactly identical; for example, in the theoretical case no reflection takes place within the wall, but the present tests indicate, from the position of the material within the resonating tube, that reflection occurs within the material as well as at its extremities. Reference to these theoretical considerations, when taken in conjunction with the results of the tests and other available data, may be of assistance in dealing with particular problems of sound absorption, or in estimating the absorption qualities of a material by examination of its composition.

It would seem that the nature of the fibres constituting the absorbent material is, within reasonable limits, of minor importance, and that it is their disposition to give a large number of similarly sized meshes, for the penetration of the sound, that gives absorbing value to the material.

The chief point to consider is the influence of the size of the meshes, or pores of a material on its absorbing properties, *i.e.*, the effects due to varying the density of packing of the material. Obviously, if an unlimited thickness of material be available, the percentage of reflection will decrease, or the percentage of absorption will increase, continuously as the pores are made wider, *i.e.*, as the density of packing is reduced. If, however, the thickness of material be limited to a specified value, two opposing influences have to be considered; one of these is the tendency of the material to admit more sound for absorption as the pores are widened, and the other is the corresponding increase in the amount of sound which passes through the material. (If there be a rigid surface at the further side of the material, sound will be reflected from this surface back through the material). Hence for a given thickness of material (and a given frequency of sound) there will be an optimum density of packing to give a maximum of absorption.

It has been shown in Section 3 that the absorption by a thin layer of absorbent material, placed in a field of standing waves, varies with the position of the material, being a maximum at a velocity loop. Under such conditions it would seem probable that the optimum density of packing will also vary with the position of the material, being least when the material is at a velocity loop. No experiments have, however, been made to confirm this conclusion.

The effect of varying the frequency of the sound is of importance, and the few tests that were made show that in all cases an increase in frequency gave increased absorption. Generally, as the frequency is increased, the sound will be more completely absorbed, and at the same time a smaller depth of material will be required. With absorbent materials, such as are used in practice, it seems certain that a limit will be imposed on the increase of absorption with increasing frequency, but, in general, no serious falling off in absorption beyond this limit need be anticipated.

When the thickness of material is limited, since the optimum density of packing, for a maximum of absorption, requires a compromise between reflection from and transmission through the material, it would seem, in general, that the lower the frequency the more should the material be compressed for maximum absorption at that frequency. This does not necessarily mean that absorption at higher frequencies will be less than at the frequency at which the density of packing is best, but that it is less than could be obtained with the specified thickness of material.

These considerations affecting absorption are by no means complete, but are sufficient to form a working basis for most practical purposes. They demonstrate that variations in the degree of absorption are liable in consequence of changes in any of the conditions of position (relative to a velocity node), density and thickness of material and frequency of sound.

The information required from the tests was merely qualitative and the numerical results obtained can only be taken to represent a first approximation. When quantitatively accurate results are required it may be necessary to purify the acoustic output from the source of sound, and to ensure that its intensity is independent of the acoustic load. If this load be varied, the intensity of the source may be maintained, for example, by means of observations on a sound pressure recording device communicating with the cavity behind the telephone receiver diaphragm. In any case the nature of the samples tested was such that differences, such as variations in the density of packing, are liable between a small sample and a large surface of material.

APPENDIX.

The Ratio method of Section 5 of the text is similar to a method described in a recent issue of the "Scientific Papers of the Bureau of Standards."*

The sound velocity measured by the Rayleigh Disc is the sum of the velocities, at the disc, of the plane wave travelling along the tube from the source and of all the ensuing reflected waves. This sum must take into account the phase as well as the direction of each of these components. Suppose that the disc is so situated that the rigid end A (see Fig. 1) of the tube is at a distance which is an odd multiple of $\lambda/4$—where λ is the wavelength of sound. It will first be assumed that waves are reflected without loss at A and without change of phase at either surface. Let V be the velocity of the initial plane wave travelling from A to B, and let kV be that of the first reflected wave (k is then the reflecting factor for the surface in terms of velocity, amplitude or pressure, all of which are proportional in a plane wave). The difference between the phases of the velocities of any of the waves is, at the disc, a multiple of π, and an infinite convergent series can be built up to represent the velocity at the disc due to the combined effect of all the waves present in the tube.

Obviously the condition referred to is that giving a maximum velocity at the disc, and, since the deflection of the disc is proportional to the square of the velocity, the maximum deflection, d_1, is related to k thus:—

$$\sqrt{d_1} \propto 1 + 2k + 2k^2 + 2k^3 + \ldots \text{ to inf.} \ldots\ldots(1).$$

$$\propto \frac{(1-k)}{(1+k)} \text{ (by summation of the series)} \ldots(2).$$

Now if the end B be moved until its distance from the disc is an *even* multiple of $\lambda/4$, the end A remaining fixed, the conditions are those obtaining when the minimum deflection d_2 is observed, and hence

$$\sqrt{d_2} \propto 1 - 2k + 2k^2 - 2k^3 + \ldots \text{ to inf.} \ldots\ldots(3).$$

$$\propto \frac{(1+k)}{(1-k)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4).$$

From equations (2) and (4)

$$\sqrt{\frac{d_1}{d_2}} = \mathrm{D} = \left(\frac{1+k}{1-k}\right)^2 \ldots\ldots\ldots\ldots\ldots\ldots(5).$$

$$\text{whence } k = \frac{\sqrt{\mathrm{D}} - 1}{\sqrt{\mathrm{D}} + 1} \ldots\ldots\ldots\ldots\ldots\ldots(6).$$

where the symbol $\mathrm{D} = \sqrt{\frac{d_1}{d_2}}$ is used for abbreviation.

It has hitherto been assumed that reflection occurs without change of phase at B; this condition is not always realised in practice. The fact that the phase relationship between the incident and reflected waves is unknown is, however immaterial to the test, since the positions for maxima and minima deflections of the disc are determined by observation, and the theory outlined above holds good whatever this phase relationship may be. This may be proved as follows:—

Suppose that, at a cross section X of the tube, near to end B, the phase difference between an incident wave and its reflected wave is ϕ, and that the distance of X from the disc is x (the position of X being considered fixed relatively to the end B). Let V Sin ωt be the instantaneous velocity of the initial wave at the disc, then V Sin $\left(\omega t + \frac{2\pi x}{\lambda}\right)$ is the velocity of the initial wave at X, and kV Sin $\left(\omega t + \frac{2\pi x}{\lambda} + \phi\right)$ is the velocity of the reflected wave at X, and kV Sin $\left(\omega t + \frac{4\pi x}{\lambda} + \phi\right)$ is the velocity of the reflected wave at the disc.

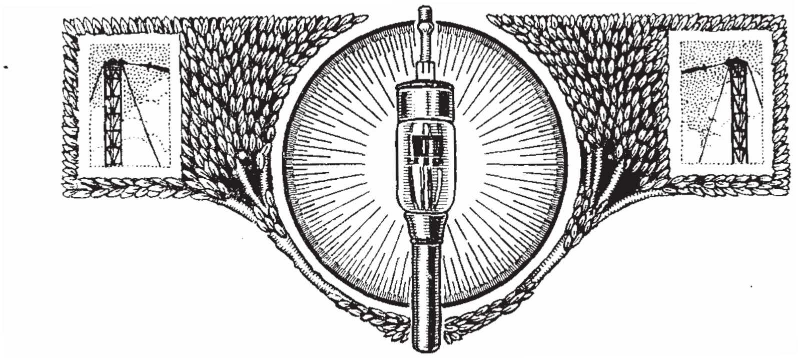
---

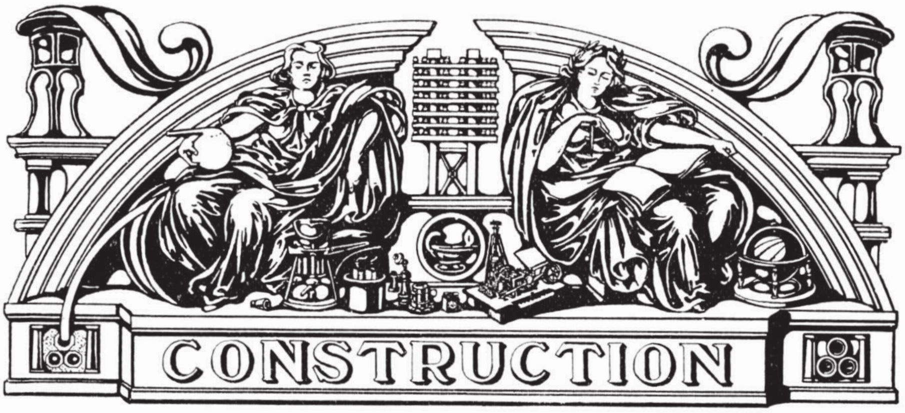
* *Vol. 21, p. 53, Paper No. 526. By E. A. Eckhart and V. L. Chrisler. The method makes use of a sound pressure measuring device—instead of a Rayleigh Disc—with some advantages which are important for the measurement of materials of low absorption.*

The instantaneous value of the velocity at the disc due to the initial and first reflected waves is therefore

$$V \operatorname{Sin} \omega t - kV \operatorname{Sin}\left(\omega t + \frac{4\pi x}{\lambda} + \phi\right)$$

Now if x be such that $\frac{4\pi x}{\lambda} + \phi$ is an odd multiple of π, the phase relationships at the disc are identical with those from which equation 1 was derived. Similarly if $\frac{4\pi x}{\lambda} + \phi$ is an even multiple of π, equation 3 holds good, and it is obvious that these conditions give respectively maximum and minimum values of the velocity at the disc.





THE ANGLO-FRENCH (1926) CABLE.

LEAD-SHEATHED, PAPER CORE, CONTINUOUSLY LOADED.

ANOTHER important link in the network of cables joining this country with the Continent was completed on the morning of the 17th March, when the cable ship "Silvergray" landed the English shore end of the Anglo-French (1926) continuously loaded telephone cable on the beach at Seabrook between Sandgate and Hythe. She had delivered the French end near Audrecelles, a village some nine and a half miles north of Boulogne, at eleven o'clock the preceding morning and had laid the cable in a continuous length, arriving off Sandgate about 5 p.m.

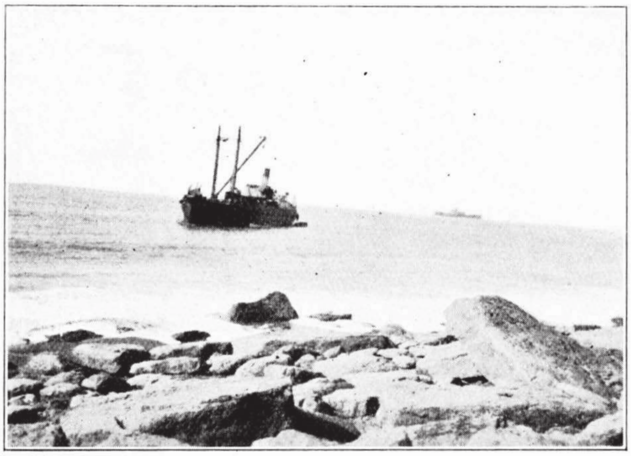


Fig. 1.—The "Drudge" going in with Shore End.

The laying of the main portion went without a hitch, except a momentary over-running of the cable on the drum just after the start. The delivery of the French end was accomplished by the use of a shallow-draught tug, appropriately termed the "Drudge," which was loaded with the necessary length of cable to extend from the cable ship to the cable hut some

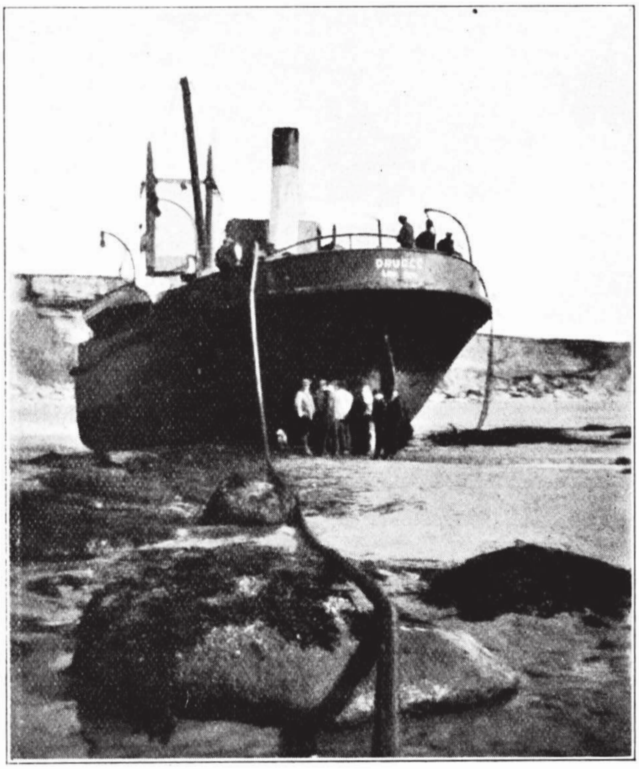


Fig. 2.—The "Drudge" and Cable at low tide.

way up the beach. The coiled cable was turned over, the lashings were cast off and the "Drudge" steamed slowly ashore at high water, paying out as she went. She sailed right in until she sat down comfortably on the bottom, fully one hundred yards above low water mark. The cable was then swung round on the beach to let her float clear on the next tide, which she did successfully without damage. Fig. **1** shows the "Drudge" steaming ashore and almost aground; Fig. **2** the tug high and dry; Fig. **3** swinging the cable round to clear the propeller; Fig. **4** the cable hut in the bents below Audrecelles.

Fig. **3**.—Swinging Cable clear.

Fig. **4**.—Cable Hut at Audrecelles.

At the English side a tug was employed to tow the barge which carried the shore end. The weather had been very fine for the season, but as the cone was hoisted indicating the approach of a gale from down channel it was decided to load up the barge and push the landing through the night. About three quarters of a mile of cable was therefore paid into the barge and turned over ready for paying out when the tug cast off from the ship. At 11.30 p.m. Mr. Elwin, of Siemens Bros., and the writer jumped on board the barge to join the cable party and at 3.30 a.m. we came ashore on the beach at Seabrook. A cinema operator had been waiting to take a film of the proceedings, but he had left when darkness fell—rather luckily for us as our landing was perhaps not so dignified as we should have wished. Four hours hanging on to the bare deck of a barge on a windy dark night in the Channel does not produce the equanimity and pose required to face a "close-up" for the movies, but it killed a bad cold which had been worrying the writer for a fortnight. Fig. **5** shows the digging party with the tug and barge in the offing; Fig. **6** the barge at 8 a.m.; Fig. **7** the testing huts over the manhole and the Research test van near the fence.

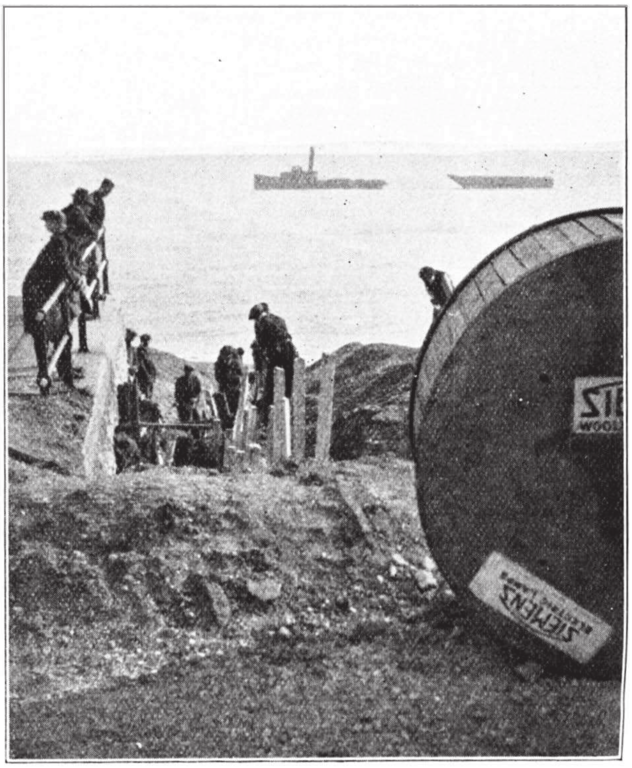


Fig. **5**.—Digging Trench at Seabrook.

Description of Cable.—The cable is of the same type and capacity as the Anglo-Belgian (1926) cable, described in the January issue of this Journal by Mr. W. T. Palmer. The block, showing the cross section of the cable and used to illustrate that description is reproduced here in Fig. **8**, the only difference between the two cables being a distinguishing black line on the white wire of the AB pair in each quad. The submarine portion, 23.9 nautical miles in length, is extended by a through joint to a land cable laid from Seabrook to Canterbury, and on the French side from the cable hut to Boulogne. These two land cables are continuously loaded and have practically the same electrical constants as the sea cable, but they are not armoured and have only one lead sheath. Their make-up is as follows:—

FIG. **6**.—THE BARGE AT DAYLIGHT.

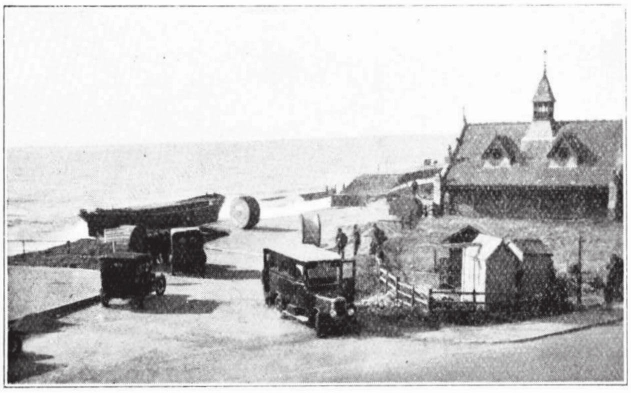


FIG. **7**.—TESTING HUTS INSIDE FENCE ABOVE MANHOLE.

Land Cables.—28 wires continuously loaded, paper core, lead-covered, made up in seven 4-wire units of quad formation. Weight of each conductor approximately 102 lbs. per statute mile. Weight of loading material 29.5 lbs. per statute mile (in the form of two iron wires wound side by side in one layer), 8 mils. diameter. Each conductor is insulated with three spiral lappings of paper, the outer paper of distinguishing colour. Four such insulated conductors are quadded upon a substantial paper centring, and the whole wrapped with an open spiral of paper of distinguishing colour. The colour scheme of conductors and of quads is as follows: R, W with black line, AB pair of quad; B, W, CD pair of quad. Spacing cores of paper are provided between the quads; the arrangement of the quads is one in the centre and six surrounding quads. Two spacing cores separating R_1, B_1 and W_1 are orange coloured; the others are white. The whole cable is fully lapped with paper and enclosed in a lead sheath having a uniform thickness of 0.107 inches, with an overall diameter of 1.42 inches.

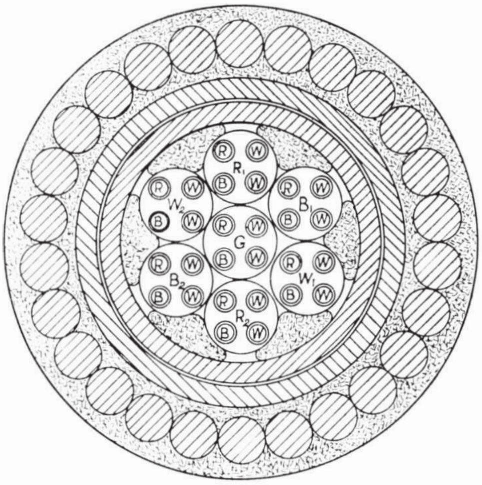


FIG. **8**.—CROSS SECTION OF SEA CABLE.

Balancing Arrangements.—After the quads were stranded into the cable, a large number of quads of appropriate length were taken and measured for inductance and alternating current resistance unbalance. From these results quads of the same colour were selected to make up quads equal in length to that of the finished drum length. In selecting the quads, crosses were allowed to be introduced between the wires of individual cores (but no crosses between the cores—since single quads only were dealt with at this stage). In jointing, the copper wire of each conductor is scarfed, the iron loading wire is replaced by copper wire of the same diameter for an inch or two and the whole is then silver soldered. The seven quads of each drum length balanced for inductance and effective resistance were then stranded into a cable in the usual manner. The drum lengths were jointed on the site into approximately $4\frac{1}{2}$ mile lengths, selections being made initially for capacity unbalance and later for impedance unbalance of the cores. The uniform distribution of the line constants with length was arranged for by grading on site.

Tests.—(1) Factory or drum lengths. (*a*) For degree of uniformity (*i.e.*, deviations from a mean value) and average magnitude of primary constants and of Z_o and β at 5000 radians per second. Comparison with results obtained on submarine portion. (*b*) For magnitude of Z_o and β at 12,500 radians per second. (*c*) For magnitude of primary constants at five frequencies, viz., 3000, 5000, 7000, 10,000 and 12,000 radians per second. (*d*) For alteration of inductance after passage of 100 *m*A, D.C. (*e*) Cross-talk between circuits.

(2) Nominal $4\frac{1}{2}$ mile Sections. (*a*) Primary and secondary constants at 5000 radians per second on representative circuits. (*b*) Z_o/f characteristics for uniformity of distribution of constants. (*c*) Effective resistance and inductance unbalance of circuits. (*d*) Cross-talk between circuits.

(3) End-to-end Tests. (*a*) D.C. insulation resistance and conductor resistance (loop and unbalance). (*b*) Z_o and β from Z_f Z_c tests of all circuits at 5000 and at 12,500 radians per second. (*c*) β and α from Z_f Z_c tests on representative circuits at five frequencies over range 3000 to 12,000 r.p.s. (*d*) Z_o/f for representative side and phantom circuits over range 3000/125,000 r.p.s. from each end. (*e*) Cross-talk between circuits.

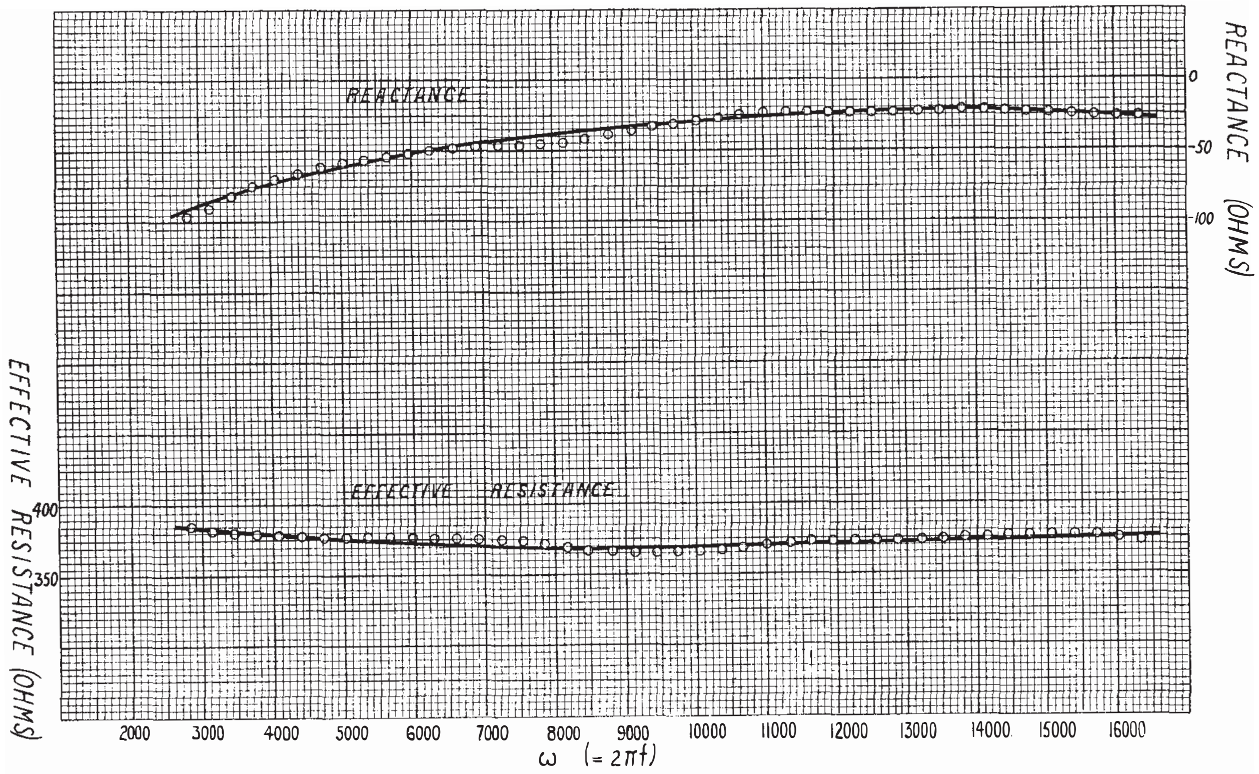


FIG. 9.—IMPEDANCE/FREQUENCY CHARACTERISTICS OF SIDE CIRCUITS. TESTED FROM CANTERBURY ON LAND LENGTH CANTERBURY-SEABROOK.

PARTICULARS OF LAND CABLE LENGTHS.

Locality—	Canterbury to Seabrook.	Audrecelles to Boulogne.
Total length—	35,022½ yds. or 19.9 miles.	16,800 yds. or 9.55 miles.
No. of lengths—	103 of approximately 340 yds. each. 55 tested.	47 of approx. 357.5 yds. All tested plus 1 spare length.
No. of Sections—	4 of mean length 4.95 miles.	2 of mean length 4.77 miles.

RESULTS OF TESTS ON ENGLISH SIDE LENGTHS.

			Side Circuits.	Phantoms.
Factory Lengths.	Average mean values per 2029 yds. at 5000 r.p.s.	R	20.5 ohms	10.1 ohms
		L	12.7 mH.	5.99 mH.
		C	0.0906 μ.F.	0.2548 μ.F.
		Z_0	385 ohms	158 ohms
		β	0.0278	0.03355
	ditto 12,500 r.p.s.	Z_0	374.7 ohms	153 ohms
		β	0.0334	0.0392
	Terminated Cross-talk Reed Hummer	S/S	Mean 53, Max. 100.	
		S/+	,, 230, ,, 616.	
		+/+	Less than 10.	
	After applying 100 mA, D.C.		δL + 0.2%	
Nominal $4\frac{1}{2}$ mile Sections.	D.C. Res. unbalance. % per Section		Mean 0.05, Max. 0.14.	
			Side Circuits.	Phantoms.
	Values for certain cores per 2029 yds. at 5000 r.p.s.	R	19.68 ohms	9.64 ohms
		L	12.37 mH.	5.73 mH.
		C	0.0900 μ.F.	0.2513 μ.F.
		G	1.2 m.mhos.	1.5 m.mhos.
		Z_0	$379.7\ \overline{\backslash 8^{\circ}\ 45'}$	$154.9\ \overline{\backslash 9^{\circ}\ 16'}$
		β	0.02643	0.03204
	Terminated Cross-talk Reed Hummer	S/S	Mean 60, Max. 130.	
		S/+	,, 230, ,, 400.	
		+/+	Between quads 20/70.	

			Side Circuits.	Phantoms.
End to end Canterbury to Seabrook.	D.C. Res.		Loop 330.9 ohms. Max., 330.3 ohms mean.	
	,,		Unbalance 0.09% Max., 0.027% mean.	
	,,		In. Res. 21,000 megohms per mile.	
	5000 r.p.s.	Z_0	$382.5\ \overline{\backslash 8^{\circ}\ 50'}$ (CU)	$156\ \overline{\backslash 9^{\circ}\ 19'}$ (CU)
		,,	$383.0\ \overline{\backslash 8^{\circ}\ 32'}$ (Seabrook)	$156.8\ \overline{\backslash 9^{\circ}\ 0'}$ (Seabrook)
	,,	β/Naut.	0.0268 (CU)	0.0324 (CU)
		,,	0.0269 (Seabrook)	0.0325 (Seabrook)
	Cross-talk. Terminated. *Speech.*	S/S	37/100 (CU)	50/80 (Seabrook)
		S/+	220/350 (CU)	220/350 (Seabrook)
		+/S	307/400 (CU)	299/500 (Seabrook)
		+/+	Nil (CU)	Nil (Seabrook)

The values obtained on the French Land Lengths, Audrecelles to Boulogne, were to all intents and purposes similar to the foregoing results.

OVERALL TESTS—CANTERBURY TO BOULOGNE.

The following are the results of the principal overall tests made on the cable, including both

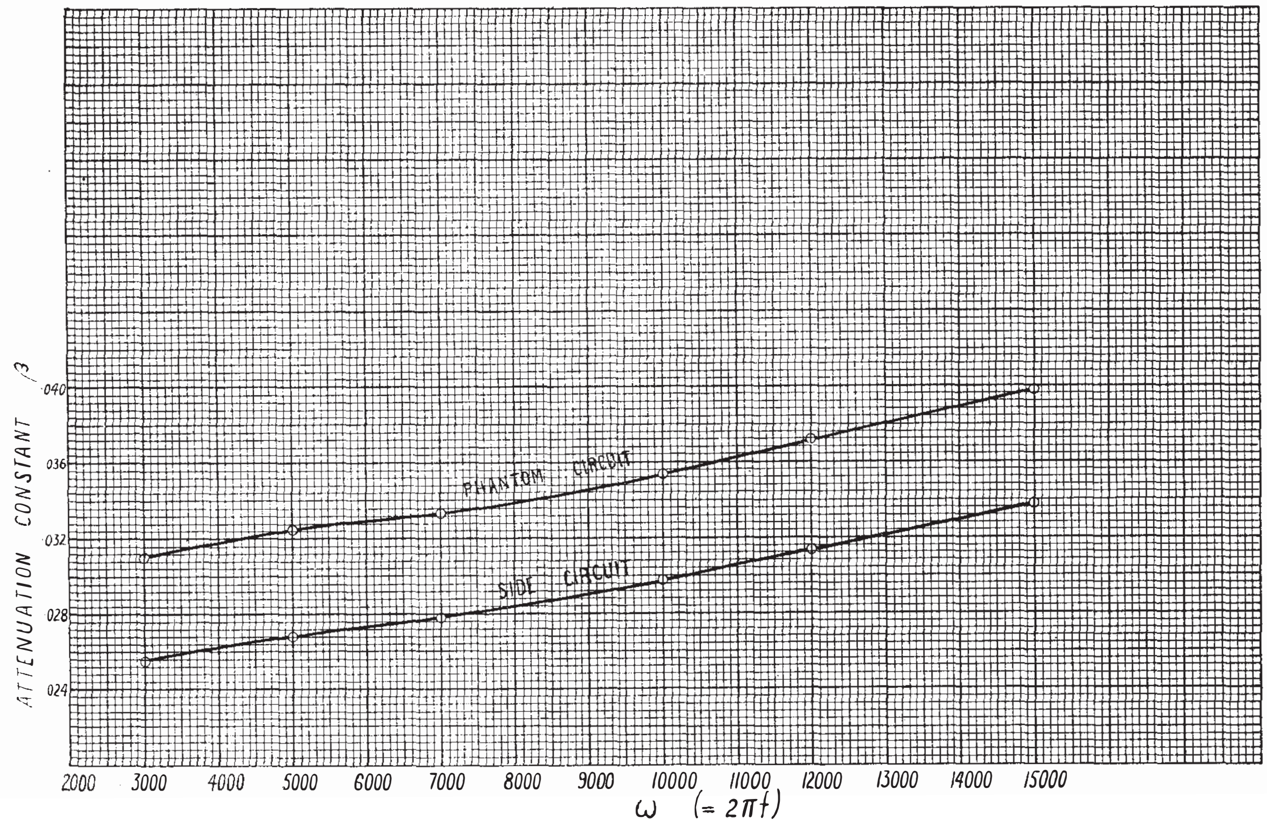


FIG. 10.—ATTENUATION/FREQUENCY. TESTED FROM CANTERBURY ON LAND LENGTH CANTERBURY-SEABROOK.

land cables and the sea portion, from the two Repeater Stations:—

D.C. Tests.

(1) Mean Insulation Resistance of each core to all the other cores earthed = 40,000 megohms per naut. after 1 minute's electrification.

(2) Mean Conductor Resistance = 9.76 ohms per naut.

(3) D.C. Capacity. Average side circuit capacity = 0.0902 μ.F. per naut. loop.

Average phantom circuit capacity = 0.2720 μ.F. per naut. loop.

A.C. Tests.

(1) Transmission Efficiency and Distortion. Each circuit was measured for its characteristic impedance and attenuation constant from both ends with a testing current of 1 *m*A at a frequency corresponding to an angular velocity of 5000 radians per second. The mean results are shown in Table I.

TABLE I.

ATTENUATION CONSTANT AND CHARACTERISTIC IMPEDANCE AT $\omega = 5000$ RADIANS PER SEC. FOR LENGTHS OF CABLE = 49.45 NAUTS.

Circuit.	Attenuation Constant per Naut. Loop $\equiv \beta$		Characteristic Impedance in Vector Ohms $\equiv Z_0 \, \lvert\phi_0$.	
	From Canterbury.	From Boulogne.	From Canterbury.	From Boulogne.
Average of the 14 Side Circuits ...	$.0273_3$	$.0273_5$	386.8 $\backslash 8^\circ\ 42'$	375.3 $\backslash 10^\circ\ 0'$
Average of the 7 Phantom Circuits	$.0329_5$	$.0328_7$	157.5 $\backslash 9^\circ\ 34'$	151.7 $\backslash 10^\circ\ 23'$

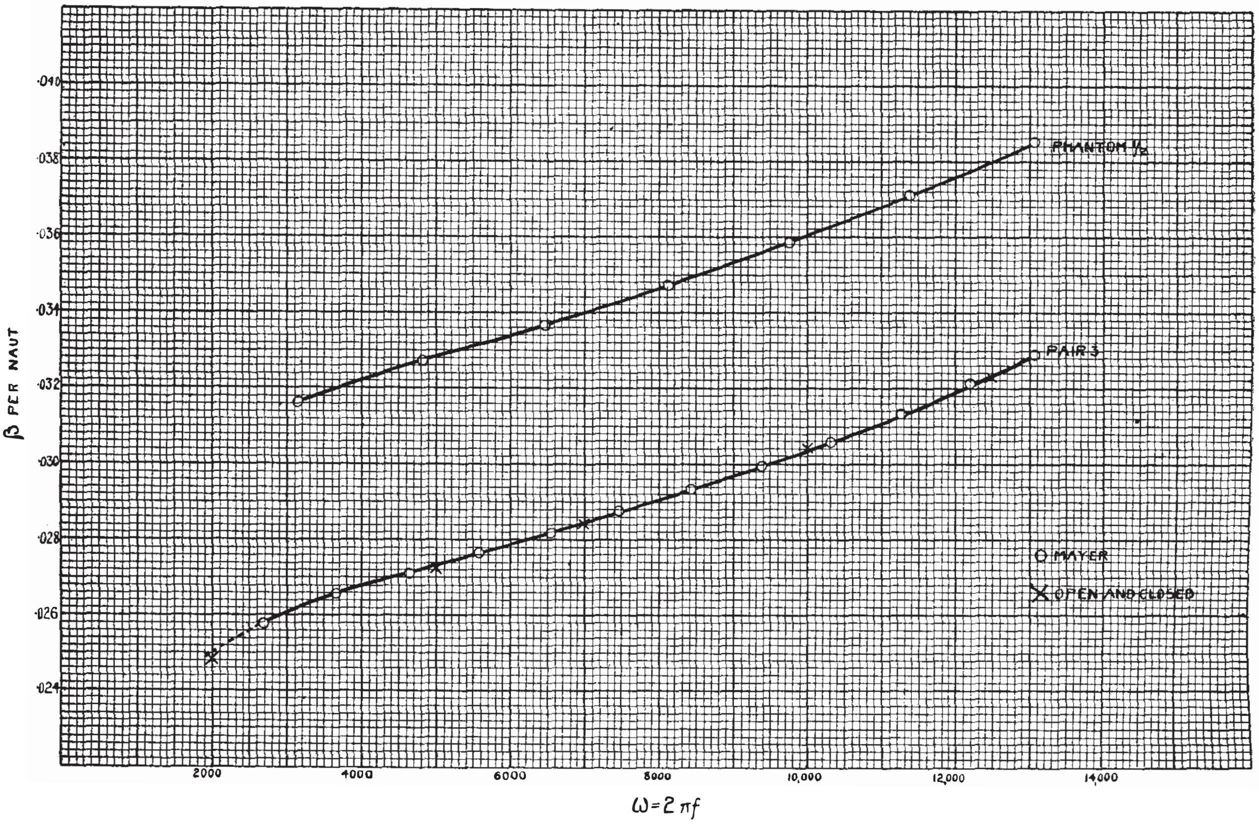


FIG. 11.—VARIATION OF ATTENUATION WITH FREQUENCY. TESTED FROM CANTERBURY BY " MAYER " AND " OPEN AND CLOSED " METHODS, CANTERBURY-BOULOGNE.

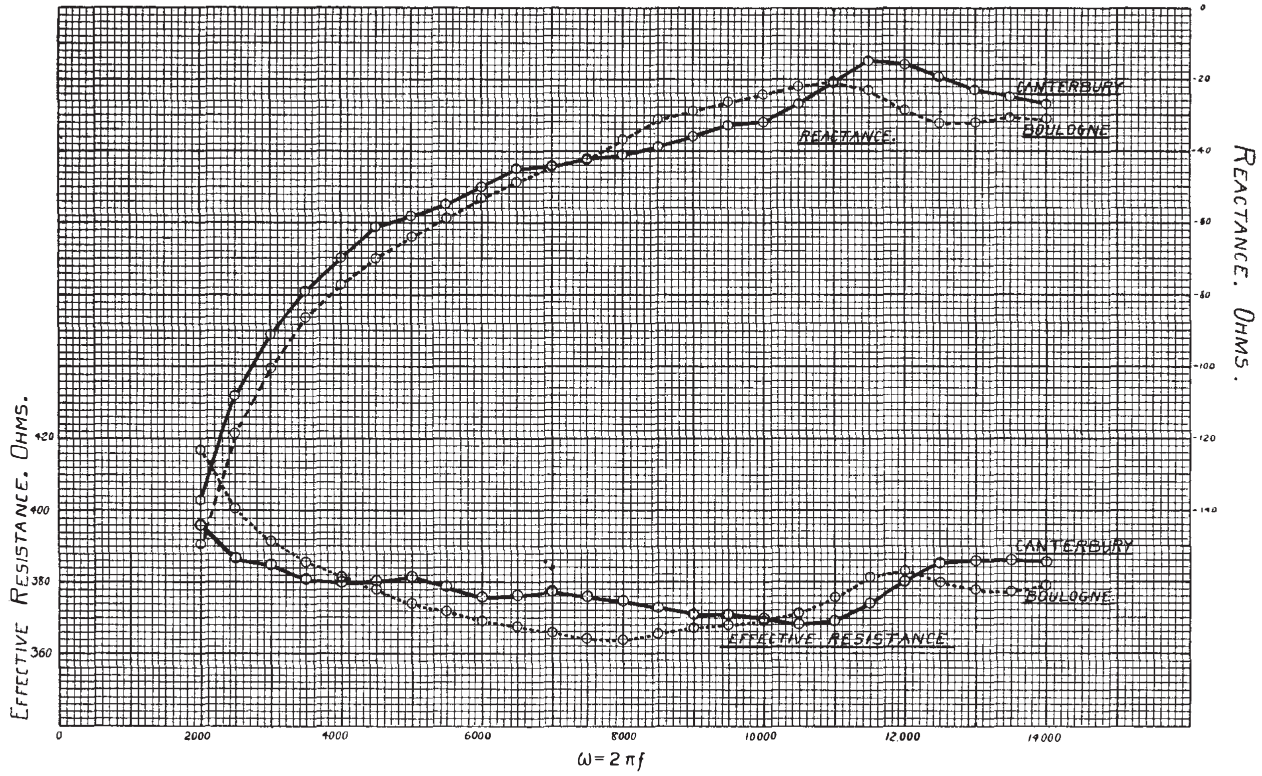


FIG. 12.—IMPEDANCE/FREQUENCY CHARACTERISTICS OF PAIR 3. TERMINATED WITH Z_0 OHMS.

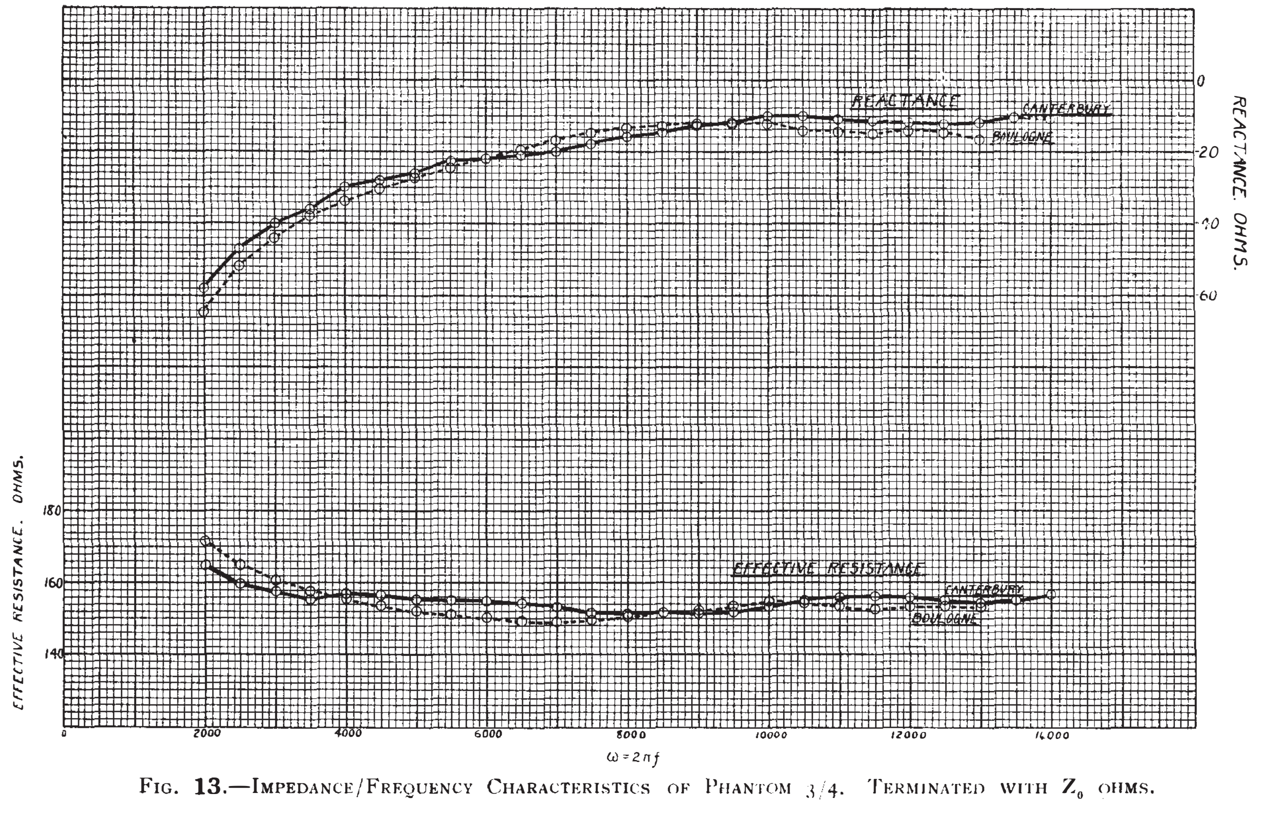


FIG. 13.—IMPEDANCE/FREQUENCY CHARACTERISTICS OF PHANTOM 3/4. TERMINATED WITH Z_0 OHMS.

From Table I. the side circuits of the cable are found to be approximately equivalent to 12.7 M.S.C. and the phantom circuits to 15.4 M.S.C.

The variation of the attenuation constant with frequency for a selected pair and phantom is shown by Table II. and Fig. **11.** This curve was obtained by the Mayer method of measuring attenuation and check tests by the " open and closed impedance " method agreed exactly with these results. From the curves in this figure it can be shown that the mean distortion for the side and phantom circuits between $\omega = 2000$ and $\omega = 12{,}500$ radians per second is equivalent to a βl of approximately .35 or an equivalent distortion of nearly 3.3 M.S.C. in either case.

(2) Uniformity of Electrical Constants. All the circuits were tested for characteristic impedance over a range of $\omega = 2000$ rads. per sec. to $\omega = 13{,}000$ rads. per sec. from Boulogne. The circuits in three quads were similarly tested from Canterbury. Figs. **12** and **13** show typical examples of the variation in Z_0 obtained from each end of the cable on one selected side and one phantom circuit. These curves are drawn to a large scale and the maximum deviation of each from a smooth mean curve is less than ± 2%, whilst in no case did the variation exceed ± 5%, the figure guaranteed by the Makers.

(3) Interference Between Circuits. Cross-Talk tests were made with the P.O. apparatus using a Western Electric Cross-Talk Meter which expresses the induced current in millionths of the inducing current.

Table II. shows the cross-talk readings obtained for circuits within each of the seven quads, while Table III. gives the results obtained for cross-talk between quads.

TABLE II.

CROSS-TALK READING FOR CIRCUITS WITHIN QUADS.

Taken with the meter in parallel and the distant end of the cable terminated by its characteristic impedance.

SOURCE OF DISTURBANCE—SPEECH.

Tests from Canterbury.					Tests from Boulogne.				
Speaking on :		Listening on :			Speaking on :		Listening on :		
Quad	Cct.	AB	CD	+	Quad	Cct.	AB	CD	+
1—2	AB	—	130	500	Green	AB	—	100	900
	CD	130	—	500		CD	100	—	800
	+	800	600	—		+	1000	1200	—
3—4	AB	—	70	300	Red$_1$	AB	—	70	400
	CD	70	—	300		CD	70	—	400
	+	400	400	—		+	700	600	—
5—6	AB	—	70	700	Blue$_1$	AB	—	100	600
	CD	70	—	400		CD	100	—	700
	+	800	600	—		+	800	900	—
7—8	AB	—	130	400	White$_1$	AB	—	70	500
	CD	130	—	250		CD	70	—	400
	+	500	400	—		+	800	600	—
9—10	AB	—	100	700	Red$_2$	AB	—	200	500
	CD	100	—	500		CD	200	—	400
	+	900	700	—		+	700	600	—
11—12	AB	—	40	300	Blue$_2$	AB	—	130	500
	CD	40	—	500		CD	130	—	1000
	+	400	700	—		+	800	1100	—
13—14	AB	—	70	350	White$_2$	AB	—	130	300
	CD	70	—	300		CD	130	—	500
	+	500	450	—		+	500	600	—

TABLE III.

CROSS-TALK BETWEEN QUADS.
END CONDITION AS IN TABLE II.
SOURCE OF DISTURBANCE—REED HUMMER.

Circuits under Test.	Maximum Reading obtained on Cross-talk Meter.	
	From Canterbury.	From Boulogne.
Side to Side ...	100	100
Side to Phantom or *vice versa* ...	40	160
Phantom to Phantom ...	<20	40

The Specified Maximum Values of Cross-Talk for the Submarine Portion were as follows:—

	Divisions on Cross-talk Meter.
Side cct. to Side cct.	400
Side cct. to Phantom cct. ...	2000
Phantom cct. to Phantom cct....	400

The complete cable from Canterbury to Boulogne, which will form the main trunk route to Paris and southwards, was manufactured and laid by Messrs. Siemens Bros., Woolwich, who also carried out all the tests on the French land side. Mr. A. Morris of the Research Section was present during the final runs at the request of the French Administration. To him and to Mr. W. T. Palmer the author is indebted for much of the information contained in the foregoing; the photos of the French side were taken by Mr. J. McA. Owen, who also assisted in the final tests with Messrs. Morris and Palmer.

W.C.

NOTES & COMMENTS

THE change in size of the Journal, which was introduced with last issue, has been received with almost general favour and we have to thank our many friends, personal and professional, for the expressions of approval and goodwill that have been extended to us in our new venture. It is to be regretted that several press notices, while congratulating the Board of Editors on the improved format, omitted to mention the very important point that at the same time our subscription had been reduced from six to five shillings per annum.

Members of the old brigade of P.O. engineers will have heard with very sincere regret of the death, on the 3rd of May, of Mr. H. Hartnell at the good old age of eighty-one years. He was one of the original members of the Board of Editors of this Journal and on his retirement in 1911 he was created a honorary member of the I.P.O.E.E. for his services in connection with the Institution. Always a worker, Mr. Hartnell continued to test materials for the Colonial services right up almost to the end and it was perhaps this life interest that enabled him to enjoy his pension for so long. The following extracts are taken from the notice on his retirement which appeared in our April, 1911, issue:—" The Engineer-in-Chief's Office loses one of its ablest officers, and his colleagues one of their best personal friends. . . . Of Mr. Hartnell's services during the twenty-seven years he worked in the Engineer-in-Chief's Office it is perhaps unnecessary to say much, as they are well known and highly appreciated. There was scarcely any class of work in which he was not more or less closely in touch, and the benefit of his ripe experience was constantly sought. At the head of the ' Examinations ' Section he had a large staff to control and very responsible duties to perform. Not only did these duties relate to the examination of physical bodies, but also to the examinations of members of the Commercial Staff for double increments and for promotion. Mr. Hartnell was particularly qualified for the task in view of his sound knowledge and tactful character. His knowledge of all matters in connection with cable (both submarine and underground) construction was extensive and thorough, and the mileage which passed under his personal observation reached an astonishing figure; indeed, his knowledge in this respect resulted in his being appointed a member of the Standard Committee."

We have received from Mr. E. H. Bennett, Manager and Engineer, a copy of the Balance Sheet, Revenue Statement and Statistics, of the Guernsey States Telephone Department for the year ended 31st December, 1926. The department appears to be in a very healthy condition. The number of subscribers' lines shows a regular yearly increase from 217 in 1898 to 3302 at the end of last year; the overhead metallic mileage in the same period rose from 146½ to 2434¼, while the underground metallic mileage rose from 2½ to 4486. The number of employees in the service of the department, starting with a total of 24 in 1898, has increased to 86. The Revenue Account for the year shows the same satisfactory result. After meeting working expenses, overheads, depreciation and sinking fund charges the account shows a balance of nett profit for the year of £762. The capital is made up of States 3% Loan (1905) £32,000, of which some £8,253 has been redeemed; States 5% Loan (1920), amount subscribed £27,150, of which £2,500 has been repaid; and States 4½% Loan (1925), amount subscribed £15,000, of which £200 has been repaid. The liabilities are fully covered by the certified plant, buildings, etc., in situ, by cash and by £9,000 5% War Loan.

Television is following rapidly on the heels of wireless. On the 7th April a public exhibition was given by engineers of the Bell Telephone Laboratories in Bethune Street, New York City, with remarkable success. The receiving apparatus was switched on to a trunk line, and an address was delivered by Secretary Herbert Hoover, in Washington over 200 miles away, which was heard well on a loud speaker, while every line and movement of Mr. Hoover's face was seen on a screen synchronising perfectly with the words. Further demonstrations were carried out between the laboratories and the experimental station at Whippany, New Jersey. While these experiments were demonstrated over line wires, there is nothing really to prevent their repetition by radio means, and the time is rapidly nearing when a wireless receiving set at home can be equipped with a screen on which the face and movements of the speaker will be seen as clearly as the sounds are heard now. Mr. J. L. Baird in this country has also been successful in his efforts in the same direction.

Mr. Frank G. Baum, a consulting engineer for the Westinghouse Electric and Mfg. Coy., has patented an arrangement whereby he claims to have solved the problem of transmitting economically large amounts of electric power over distances of several hundred miles. The invention " covers the connection of a plurality of automatically regulated synchronous condensers at suitable intermediate points directly to a high-voltage transmission line." These so-called synchronous condensers are really special motor-alternators operated from the line which automatically regulate the electrical characteristics of the line itself and change the capacity of the system in accordance with requirements to maintain constant voltage with varying power demands. With the development of the Shannon scheme in Ireland, the Lochaber hydro-electric development in Scotland and the start about to be made by the Electricity Commissioners in the Central Scotland area, the necessity for maintaining the voltage of the grid constant with widely-varying loads is at once apparent, if the advantages of standardisation are to be fully secured in this country. Mr. Baum speaks confidently of the coming of a power line which will be fed from the water power of the Rockies and will serve economically the electrical requirements of the Mississippi Valley.

We regret to announce the death of Mr. W. H. Winny, O.B.E., Assistant Staff Engineer, Test Section, who was just entering his sixtieth year. He has been suffering from ill-health for some time and passed away in a nursing home on the 31st of May. He was an enthusiastic officer of the St. John's Ambulance Association, and did very good work during the trying period of the air raids. We hope to give a fuller sketch of his career in our next issue.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

Following works have been completed:—

Exchange.	Type.	No. of Lines.
Harrogate	New Auto.	2600
Chesterfield	,,	925
Staveley	,,	50
Halifex	,,	3100
Attercliffe	,,	1000
Ecclesfield	,,	200
Oughtibridge	,,	100
Woodhouse	,,	200
Brighton	,,	3360
Hove	,,	2940
Rottingdean	,,	130
Preston	,,	740
Portslade	,,	214
Morningside	,,	2340
Murrayfield	,,	1600
Newington	,,	1980
Sloane M.F.	,,	
Portsmouth	Auto. Extn.	4 Posns.
Wallington	Manual New.	2900
Newcastle Relief	,,	2140
Dartford	,,	530
Sheffield	,,	50 Posns.
Wellington (Salop)	,,	480
Mill Hill	Manual Extn.	760
Nelson	,,	260
Jesmond	,,	520
Carlisle	,,	400
Birmingham, North	,,	960
North (London)	,,	1300
Darlaston	,,	40
Blackpool	,,	1600
Enfield	,,	760
Birmingham, South	,,	1360
Barnet	,,	760
Weston-Super-Mare	,,	460
Birmingham, East	,,	380
Palmers Green	,,	1630
British Xylonite	P.A.B.X.	10
Greatrix, Junior	,,	30
Blackley Co-op.	,,	30
Calico Printers	,,	40
Maypole Dairy	,,	80
Britannia Assn.	,,	40
Leyland Rubber	,,	30
Bury Co-op.	,,	50
Illustrated News	,,	70
Connolly's	,,	30
Vickers	,,	160
Carpet Manufacturers	,,	40
Player & Sons	,,	80
Kaye & Sons	,,	60
Royal Arsenal Co-op.	,,	60
Macclesfield Co-op.	,,	30
Reading Bd. of Guardians	,,	30
Sheffield Corporation	,,	130
Hove Council	,,	50
Castener Kellner	,,	70
Beswick Co-op.	,,	40
Monks Hall & Co.	,,	30
Bristowe Tarvia	,,	60
Beattie's	,,	30
Dorset Council	,,	60
Taylor & Co.	,,	30

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
Metropolitan	New Auto.	9500
Lofthouse Gate	,,	100
Cosham	Auto. Extn.	200
Roundhay	,,	850
Ecclesfield	,,	90
Headingley	,,	500
Shrewsbury	,,	300
Chapletown	,,	810
Hurley	,,	30
East Grinstead	Manual New.	460
Bishops Stortford	,,	460
Rainham	,,	740
Horsham	,,	720
Garston	,,	1400
Goole	,,	500
Sutton	,,	4880
Harpenden	,,	700
Cobham	,,	600
East (London)	Manual Extn.	1410
Lee Green	,,	2240
Doncaster	,,	340
Walton (Liverpool)	,,	420
Wilmslow	,,	340
Maryland	,,	1340
Monks Hall & Co.	P.A.B.X.	30
Burris & Sons	,,	30
Vickers Sons & Co.	,,	30
Berkshire Hospital	,,	50
Bristowe Tarvia	,,	60
Butlers	,,	30
Beattie's	,,	30
Synthetic Ammonia	,,	200
Trades Union	,,	100
Lipton's Ltd.	,,	100
Taylor. W. T.	,,	30
Shell Mex (N. on T.)	,,	20
Carlisle Co-op.	,,	30
Asquith, Wm.	,,	30
Harrods Stores	,,	670
,, Estates	,,	50
Cumberland Council	,,	40
Hall, J. & E.	,,	100
Union Cold Storage	,,	40
Liverpool Warehousing Co.	,,	60
Heinmann	,,	30
Salter, G.	,,	40
Lunn's Tours	,,	20
Shell Mex (Stroud)	,,	40
Accles & Pollock	,,	50
Goodyear & Sons	,,	30

THE THIRD CONFERENCE OF THE INTERNATIONAL ADVISORY COMMITTEE ON LONG DISTANCE TELEPHONE COMMUNICATION.

THE annual conference of this Committee (referred to elsewhere as the "C.C.I.")* was held in Paris from the 26th November to the 6th December, 1926.

M. Milon, the re-elected president, emphasised the increased importance of the Committee, resulting from its recognition by the International Telegraph Union, whereby the C.C.I. membership will embrace delegates from other than European countries. In view of the objects of the Committee in organising the extending international telephone communication, the admission of delegates from other Continents for participation in its work is the natural result of the increasing range of commercial telephone communication.

The work of the conference was undertaken in sections as hitherto, and a summary of the recommendations of the Committee is given hereafter.

General Organisation.

It was agreed by the Commission on General Organisation that the C.C.I. shall comprise the General Assembly, a General Secretary elected by the assembly, and a series of commissions of reporters (" rapporteurs "); that the plenary assembly shall meet annually and that all delegations shall have the same voting power.

The full assembly will determine the work of the commission of reporters, nominate the administrations participating, and undertake the duty of accepting, rejecting or modifying all reports presented by those commissions. Further, it will appoint the General Secretary and three Auditors. The commissions are authorised to invite experts in the telephone industry to participate in their deliberations.

In addition to the regular secretarial duties, the General Secretary is authorised to take part, when desirable, in the meetings of the commission, and is also charged with the duty of collating their reports; and circulating them to all administrations adhering to the C.C.I., at least one month before each annual meeting of the full assembly.

Telephone Engineering Sub-Commission.

This sub-commission, under the presidency of the Engineer-in-Chief of the British Post Office, issued recommendations of importance in connection with matters of standardisation and maintenance. The decision to establish a European master reference standard of telephone transmission in Paris for the calibration of the working standards of the various administrations is evidence of the standardisation which is resulting from the committee's labours. The equipment, which is a replica of the apparatus constituting the Bell system standard is being constructed in America and should be installed in the Autumn of this year.. In connection with a standard unit for expressing measurements of transmission, it was not possible to arrive at unanimous agreement upon the adoption of either the natural or the decimal logarithmic telephone transmission unit. Each Administration is therefore left free to use either of these units in its internal and international relations, and no Administration has the right to demand the exclusive use of the unit it has adopted. In due course, the British standard mile will be replaced by one of these units. It was agreed that in technical literature, and in the documents of the C.C.I. in particular, transmission equivalents, losses, or gains shall be expressed in both units.

The committee has now rigorously defined most of the expressions used in telephone transmission problems, and its recommendations now embrace every aspect of international line construction, maintenance and supervision. Unanimous agreement was reached upon most of the questions referred for study by the previous assembly. These recommendations included the method of expressing frequency, the limits of overall attenuation on international circuits at 800 p.p.s. under all conditions of service, and the total permissible losses in the connection of a subscriber to his international exchange. The recommendation has particular regard also to the quality of speech, in that the transmission frequency characteristics must be made to conform to prescribed limits by the use of attenuation equalisers and by the use of specified types of loading. The use of echo suppressors was recommended for circuits exceeding specified lengths which had been determined experimentally.

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* *Comite Consultatif International des Communications telephoniques a grande distance.*

The administrations were invited to study the "transient" problems that arise in connection with circuits of greater length than 800 km. In this connection the suggestion of the German Administration to consider the limitation of the transmitted frequency range, with a view to "transient" elimination, is of interest.

Particular attention was directed to the homogeneity of international circuits and particularly to the preservation of uniform line characteristics between adjacent repeater stations. Limits were agreed upon for the terminal impedance of international circuits.

It was recommended that all subscribers' telephones used for international calls shall be tested once each year and investigations are in progress with a view to obtaining uniformity in the testing methods employed.

The recommendations in connection with the maintenance and supervision of international circuits do not present any feature not already embodied in the existing instructions upon the maintenance of Post Office aerial and repeater trunk circuits, except that noise and cross-talk limits are imposed. The tests to be employed are clearly prescribed and scheduled and particular attention is directed to the restoration of service by the replacement of defective sections of circuits by other lines with suitable transmission characteristics.

The possibility of use of international circuits for relaying radio transmission was considered and the necessary transmission characteristics of lines for both music and speech transmission are announced.

The study of simultaneous telegraphy and telephony in cables and particularly the development of international voice frequency telegraph systems is proceeding.

The existing publications of the C.C.I. on engineering matters were revised and have since been reissued in a volume known as the "Livre blanc." This volume, with its annexes and bibliography, forms a most valuable treatise on modern telephone engineering practice. An English translation of the Engineering Section will be issued shortly.

The Sub-Commission on Traffic and Exploitation.

Under the presidency of Mr. Van Embden (Holland) the traffic sub-committee reviewed all previous recommendations and the rules governing transit traffic were passed without material modification. A number of practical administrative and traffic questions were also discussed outside the formal committee meetings.

Protection of telephone lines from extraneous interference.

Dr. Breisig (Germany) presided over the meetings of the sub-commission dealing with protection against power circuits. The questions arising out of inductive interference and allied matters involved consideration of so many reports that the discussion of reports referring to the protection of lead covered cable against the effects of electrolytic and chemical action had to be postponed for consideration at the next conference.

The question of inductive interference involved the consideration of acoustic shock, induced charges from insulated power networks, electro-magnetic effects produced by short circuits on power systems, the characteristics of harmonics produced by machines of continuous current traction systems, inductive noise limits in overhead telephone cables, the effects of earthing the neutral points of 3-phase power systems and the importance of arranging for the reliable conductivity of the rails on electric traction systems using single and polyphase currents.

Exhibition of Telephone Equipment.

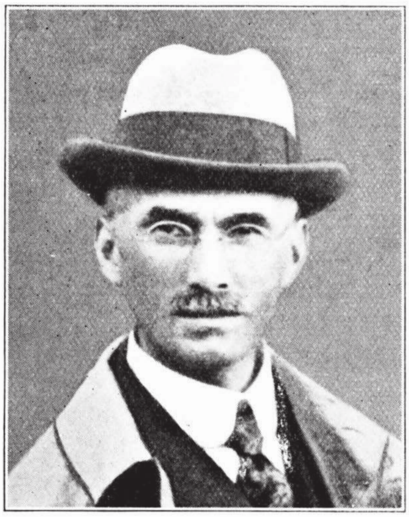
An exhibition was held with a view to presenting the latest technical developments in the equipment employed in long distance telephony. The British Post Office exhibit included many of the devices which have been referred to and described in the reports of the C.C.I.

The relations between the delegates were most cordial and the progress achieved has been very rapid and is a happy augury of the future of long distance telephony.

The Commission's recommendations and details of the various limits imposed will form the subject of short articles in future issues of the Journal.

RETIREMENT OF MR. M. RAMSAY.

To those engineers who have grown up, as it were, with the Post Office Telephone Service, the retirement of "M.R." came as a shock would come to a building which had been suddenly bereft of one of its main members. No engineer had been so intimately and so long associated with the development of the apparatus side of the telephone service as Mr. Ramsay. Since the days when Sir John Gavey came back from America with the C.B. system in his pocket the initials "M.R." can be traced on the official diagrams, right through the series of P.C., C.B.S., C.B. and Auto. It is perhaps in connection with the C.B. circuits and exchanges that Mr. Ramsay was best known to the outside engineer, although he had mastered the intricacies of the latest automatic practice as thoroughly as he had assimilated the C.B., and in his capacity as Staff Engineer in charge of the Equipment Section he was responsible for the equipment and installation of all exchanges, manual and automatic, erected by contractors for the last twelve years.



MR. M. RAMSAY.

When the P.O. started the telephoning of London, his old digs in Colebrook Row was open house to all interested in telephone matters and he freely communicated the information which he himself appeared to acquire so easily. His open-handedness in this respect was continued right up to the end, for after his return from America he gave a series of lectures to his staff and distributed complete sets of diagrams of the Panel system developed in the States and which at one time loomed large on our own horizon. He never spared himself, either on behalf of the Department or of the staff, and it is not going too far to say that had he been less of a stickler for duty he would have been stronger in health to-day. That was, however, always Magnus's way. His job was his first thought—get on with the work and play afterwards. He was always ready to take on a difficult piece of work which others had attempted and many laborious nights he spent in producing "clean" and reliable circuits and methods out of chaos.

Mr. Ramsay entered the P.O. service as a telegraph messenger at Aberdeen in 1885 and in 1890 he was appointed telegraphist in the same office. He was not content to remain in that capacity and devoted most of his spare time to studying technical subjects. He kept fit by walking and running long distances with the local P.O. harriers. He just missed winning the Long Distance Championship of the North of Scotland by inches in a stirring race in the spring of '95. He began his career in the Engineering Department as a Junior Clerk in Scotland West in 1896 and three years later he was transferred to a 3rd Class Clerkship in the E.-in-C.'s Office. In 1901 he was promoted to the rank of Second Class Engineer, and in 1904 he took first place in a keenly contested examination for the post of Second Class Technical Officer. In the same year those officers received a new stock description and became Staff Engineers Second Class, while later, in the re-organisation of 1911, the same men were re-christened Assistant Staff Engineers. During this period Mr. Ramsay was attached to the Telephone Section, but when the Company was acquired the Designs Section took charge of exchange equipment, specification and installation work, and Mr. Ramsay was placed in control of the group. The work grew to such an extent that a separate section—now one of the largest at headquarters—was formed in 1915 with Mr. Ramsay as Staff Engineer in charge. The decision of the Department to introduce automatic working in the provinces, and later in London, involved a tremendous amount of work and the Equipment Section grew in response—although the growth of the staff was, we are afraid, always lagging in phase behind the work. Heavy responsibility was thrown on the head of the section, but it was never shirked.

Strenuous work on committee in connection with the development of the London schemes and a trip to the United States to study and report on the Panel and other systems were features of the last few years. The trip to America did him little good from the health point of view, as he was suffering from a severe cold at the time and the climatic conditions of the States were not then at their best. Shortly after his return Mr. Ramsay tried a spell in the King Edward Sanatorium at Midhurst, but the improvement was only temporary. His health gradually grew worse, and after struggling gamely, as was his wont, for months he had to give up and retired from the service on the 22nd March, at the age of 56. While at Glasgow Mr. Ramsay was C. and G. Medallist in Honours Telephony and in 1900 he repeated his success and won the Silver Medal in Honours Telegraphy. For the past few years prior to his retirement he was examiner for the City and Guilds Telephony examinations.

By his staff he was admired and loved. Strangers may have considered him reserved, and even taciturn at times, but this trait is only a shell that shelters a most kindly, straight and strong personality. The writer of this all too brief notice has been a privileged friend since the salad days and he can say with assurance that in all these years he never knew Magnus to perform a single action which was not clean and without guile. Mr. Ramsay was quietly proud of his profession and it is doubtful whether there is a telephone engineer in the world with a wider knowledge and a stronger grip of the problems involved in the provision of modern exchange equipments.

His staff was anxious to give him some token of the regard in which he was held and as he has many friends scattered all over the service they were invited to participate. As a result Mr. Ramsay was presented privately, on the 6th May, with a gold English lever watch, suitably inscribed, and a gold bracelet watch for Mrs. Ramsay. His son, who is an Honours B.Sc. of London University, was second in the last open competition for Probationary Assistant Engineers, and his daughter, also an Honours graduate in Arts of London, is completing a course at Cambridge.

Since he was relieved of the strain at the Office Mr. Ramsay has taken things quietly, and he has certainly not gone backwards. After a life of service, hard enough in the early days, we know, and always faced with a cheery equanimity even when the work was heaviest and the physical frame on the verge of breaking down, it is surely not too much to hope that his indomitable spirit will yet have its reward in many years of ease and tranquility.

W.C.

MR. H. A. McINNES.

HAD he lived another twelve months Mr. McInnes would have entered his sixtieth year and been looking forward to a whole time devotion to his favourite hobby, the improvement of gramophone sound boxes. This was not to be, however, and to the sincere regret of his many friends he passed away on the 11th January.

Shortly after he joined the Designs Section in 1924 it became evident he was not in a good state of health and that it was only his indomitable courage which enabled him to remain on duty. In 1925 he underwent a serious operation and from this he really never recovered. The untimely deaths of his colleagues and near neighbours, Messrs. J. H. Thow and W. Pennington, came as a severe shock and tended to depress his naturally cheery disposition. It is also probable that the change from the active life of a country section to a sedentary job at headquarters had its effect.

Mr. McInnes began his official career in Hull, that nursery of British P.O. engineers, and from a learner in 1883 he graduated as telegraphist in 1885. He entered the Engineering Department as a Junior Clerk in the N.E. District in 1891 and seven years later he succeeded Sir William Noble (then of course Mr. W. Noble) as Second Class Engineer at Aberdeen. He was promoted to First Class Engineer at Oxford in 1905 and Executive Engineer on the revision in 1911. He was therefore in the City of Colleges for nearly twenty years and took full advantage of the educational facilities and higher social life which a University town affords. His son, N. A. McInnes, B.Sc., was a well-known figure in the University for years and represented his 'Varsity in many athletic contests, his special forte being the 3 miles foot race, at which distance he was for several years unequalled. He is now in the service of the Morris Car firm and making good there as he did on the running track. A daughter remains with Mrs. McInnes to mourn the loss of one of nature's gentlemen.

The late Mr. H. A. McInnes.

J.J.M.

LONDON DISTRICT NOTES.

During the quarter ended 31st March, 1927, the nett increase in the number of Exchange lines and extensions were respectively 8234 and 6132.

Mileage Statistics.

The following changes have occurred during the March quarter:—

Telegraphs.—A nett decrease in open wire of 24 miles and a nett increase in the underground of 29 miles.

Telephones (Exchange).—A nett decrease in open wire (including Aerial Cable) of 1,471 miles and a nett increase in underground of 84,157 miles.

Telephones (Trunk).—A nett decrease in open wire of 41 miles and a nett increase in underground of 2,212 miles.

Pole Line.—A nett increase of 31 miles, the total to date being 5,665 miles.

Pipe Line.—A nett increase of 650 miles, the total to date being 8,554 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,609
Telephones (Exchanges)	1,989,575
Telephones (Trunks) ...	66,307
Spares	114,500

Internal Construction.

A new Exchange was opened at *Wallington* on the 16th March last with the transfer of 1200 lines. The work was completed in advance of the original scheduled date and was carried out without a single fault being recorded.

An extension of the *Enfield* Exchange, which was commenced on the 11th January last, was completed and brought into use on the 13th April.

An extension of 600 lines is being carried out by the Standard Telephones and Cable Company at *Reigate* Exchange. The work was commenced on the 13th April last and completion is anticipated early in August.

The Contractors' work at *Holborn Tandem* Exchange is completed and the equipment is now under test. The first 79 positions have been allocated for experimental traffic to 33 Manual Exchanges where the C.C.I. apparatus has been completed.

Progress is being made with the 5 Automatic Exchanges under construction in the District

—*Holborn, Bishopsgate, Sloane, Western* and *Monument.* It is anticipated that the three first-named Exchanges will be brought into public service during the year. The changing of subscribers' apparatus in connection with these three exchanges is well in hand.

TELEGRAPHS.

Pneumatic Tubes in New Grand Stand at Epsom Racecourse.—A system of pneumatic tubes has been installed in the new Grand Stand at Epsom Racecourse. A 3″ gravity tube linking up the Press Gallery on the 3rd Floor with the Telegraph Office on the 2nd Floor has been fitted, and a $1\frac{1}{2}''$ tube, capable of working in both directions, has been installed between the Members' Counter on the Ground Floor and the Instrument Room. It is anticipated that the system will be extended at a later stage, when an electrically-worked blower will supersede the hand-operated pump.

Kiosks.—During the past two months 40 Kiosks No. 2 have been erected in the London Engineering District. The brilliant colour of the Kiosk is a welcome one and is a stage towards the realisation of the "Brighter London" ideal.

R.A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

The Annual General Meeting of the Institution was held at the Institution of Electrical Engineers, London, on Tuesday, May 10th, 1927.

The Chair was taken by the President, Col. T. F. Purves, M.I.E.E.

The business included the following items:—

1. Presentation of Annual Report of Council.
2. Presentation of Statement of Accounts for Year 1926-27.
3. The Annual Report and Statement of Accounts were accepted.
4. Vote of thanks to retiring Members of Council passed.
5. Presentation by President of Medals for Session 1925-26, and Booth-Baudot Award.

MEDALS FOR SESSION 1925-26.

In view of the fact that three medals only were awarded for Session 1924-25 the Council decided to make five awards for the Session 1925-26 as follows:—

Senior Silver Medals to Messrs. E. S. Ritter and G. P. Milton, for Paper No. 110 on "Testing of Telephone Circuits and Apparatus with Alternating Currents."

Senior Bronze Medal to Mr. F. O. Barralet, for Paper No. 108 on "Some Applications of Optical Methods to the Examination of Engineering Materials."

Junior Silver Medals to Capt. H. Hill, for Paper No. 105 on "The Engineering Aspect of Telephone Exchange Accommodation," and to Messrs. G. F. O'dell and W. W. Gibson, for Paper No. 107, "Automatic Trunking—in Theory and Practice."

Junior Bronze Medal to Mr. F. Johnston, for Paper No. 102, on "The Law of Contract in relation to P.O. Engineering Contracts."

BOOTH-BAUDOT AWARD 1926-27.

Mr. A. T. Sadler's suggestion for a new design of platen holder for Morkrum Teletype No. 2A has been adopted by the Department, and for this device he was presented with the award for the year.

PRINTED PAPERS.

The following is a list of the printed papers issued to the Membership during the year:—

No. 102. "Law of Contract in relation to P.O. Engineering Contracts," F. Johnson, A.C.I.S.

No. 103. "Automatic Switching Methods in Multi-Exchange Systems," H. H. Harrison, M.I.E.E.

No. 104. "Cable Testing," E. S. Ritter, D.F.H., A.M.I.E.E.

No. 105. "The Engineering Aspect of Telephone Exchange Accommodation," Capt. H. H. Hill, B.Sc., M.I.E.E.

No. 106. "Notes on Cabling Work and Labour Saving Tools," R. C. Balcombe, A.M.I.E.E.

No. 107. "Automatic Trunking—in Theory and Practice," G. F. O'dell, B.Sc., A.K.C., M.I.E.E., and W. W. Gibson.

The following papers are in the press and will be issued shortly:—

No. 108. "Some Applications of Optical Methods to the Examination of Engineering Material," F. O. Barralet, M.Inst. Metals, A.M.I.E.E.

No. 109. "The Problem of Flexibility in Subscribers' Cable Distribution," Harvey Smith.

The Annual Meeting was followed by a meeting of the London Centre at which a paper was read by Mr. C. W. Brown, A.M.I.E.E.

The paper read by Mr. Brown was on "Some Notes on Automatic Working," of which the following is a brief summary:—

P.B.X. arrangements in Automatic Exchanges.

Large groups
Medium groups } Standard schemes.
Small groups
Use of divided multiple on small groups.
Small groups } Siemens No. 16 system.
Large groups
Night service arrangements.

The facilities explained were demonstrated on a working equipment very successfully by Mr. Brown.

COUNCIL FOR THE YEAR 1927-28.

The constitution of the new Council will be as follows:—

Chairman—Mr. A. L. DeLattre.
Honorary Treasurer—Mr. B. O. Anson.
Representing Staff of the Engineer-in-Chief's Office—
Mr. C. J. Mercer and Mr. E. J. Wilby.
,, Executive Engineers—
London: Mr. J. Cowie.
Provinces: Mr. S. Upton.
,, Asst. & Second Class Engineers—
London: Mr. P. G. Hay.
Provinces: Mr. A. E. White.
,, Chief Inspectors—
London: Mr. J. D. Boulton.
Provinces: Mr. A. S. Carr.
,, Clerical Staff—
London: Mr. E. T. Larner.
Provinces: Mr. H. Longley and Mr. H. Willcock.
,, Inspectors—
London: Mr. C. W. Messenger.
Provinces: Mr. Thos. Davidson.
,, Draughtsmen—
London and Provinces: Mr. J. Millett.
Secretary—Dr. R. V. Hansford.

LOCAL CENTRE NOTES.

SOUTH LANCS. CENTRE.

Since the last notes were forwarded from this Centre the proceedings for the 1926-27 session have been completed. The further papers read are as follows:—

1926.
Dec. 6th. "Economics of Line Plant Provision." H. Kitchen, M.I.E.E.

1927.
Jan. 17th. "Motor Transport." T. Kenyon.
Feb. 7th. "Problems in large Underground Works." J. Cleaver, A.M.I.E.E.
Mar. 7th. "Voice Frequency Telegraphs." W. Cruickshank, M.I.E.E.

The high standard attained by authors of papers read before this Centre during recent years was fully maintained and the lectures by experts from the Engineer-in-Chief's office were specially appreciated. The paper by Mr. W. Cruickshank on "Voice Frequency Telegraphs" proved to be of outstanding interest, both to the local membership and to the considerable number of visitors from the Surveyors Staff and Engineering firms who honoured us by their presence. Mr. Cleaver's paper dealing with difficulties encountered and surmounted in connection with Manchester Main Automatic Duct Scheme was also particularly interesting and instructive.

The programme included a further paper on "Telephone Repeaters, Operation and Maintenance," by Mr. J. E. Statters, but it is regretted that owing to the illness of the author he was unable to complete it in time for this session. It is hoped, however, that he will visit Manchester to read it early next session.

On March 16th the members visited the extensive works of the British Insulated Cable Co., at Prescot. Approximately 90 participated in the visit and as access to the works is not very convenient by rail the parties were conveyed by motor char-a-bancs and buses from Manchester and Liverpool respectively.

The proceedings of the session were on the whole very successful, but a gloom was cast over the later meetings by the knowledge of the very serious illness of the Chairman, Mr. W. J. Medlyn, who was stricken with pneumonia on January 19th. (Mr. Medlyn has now happily recovered). The last I.P.O.E.E. Meeting at which he presided this session was that of January 17th, when Mr. T. Kenyon read his paper on "Motor Transport." At the subsequent meetings the Chair was ably filled by the Vice-Chairman, Mr. T. E. Herbert, who on each occasion expressed the very genuine regret of everyone at the circumstances which precluded the Chairman from officiating as usual. This was endorsed by a unanimous vote of sympathy coupled with the wish for his speedy recovery, which is recorded in the minutes of the meeting on February 7th.

The Local Committee for the session 1927-28 will be constituted as follows:—

Chairman: W. J. Medlyn.
Vice-Chairman: T. E. Herbert.
Executive Engineers' Representative: C. Brocklesby.
Assistant Engineers' Representative: R. C. Balcombe.
Chief Inspectors' Representative: A. Kemp.
Inspectors' Representative: R. J. Vernon.
Draughtsmen's Representative: J. C. Beaumont.
Clerical Representative: J. Mawson.
Librarian: W. N. Whittaker.
Local Secretary: C. E. Morgan.

NORTHERN CENTRE.

The last meeting of the Session was held at West Hartlepool on the 8th March, when Messrs. W. A. Nicholson and R. Parker read a paper on the "West Hartlepool Exchange Transfer." Prior to the meeting the members, to the number of 83, were marshalled into conveniently sized groups and shown over the new Automatic Exchange (Siemens No. 16). Experts, stationed at suitable points, explained the operation of the apparatus and the visit was thereby made as interesting and instructive as possible.

A description of the transfer from Magneto to Automatic switching at West Hartlepool was given in the January issue of this Journal. The joint paper of Messrs. Nicholson and Parker, who contributed the External and Internal portion respectively, dealt in a detailed manner not only with the actual transfer operations but with the organisation which was evolved to ensure that all preliminary steps received prompt and adequate attention. Particulars were given of the various means adopted for maintaining steady progress and for ensuring satisfactory results. The paper was illustrated with lantern slides and should be invaluable to members for reference purposes.

After the meeting a pleasant social gathering took place at Birks's Cafe, where the members partook of light refreshments.

SCOTLAND EAST CENTRE.

SESSION 1926-1927.

The Session was opened on 30th November by Mr. J. Innes, B.Sc., with a descriptive paper on "Messrs. Siemens' Automatic Impulse Sender." The paper provides a useful addition to the literature on Automatic Telephony and is reproduced in this Journal. The Local Committee were particularly indebted to Mr. Innes for filling a vacant date at only a week's notice. Mr. Innes's paper appears elsewhere in this issue.

Much valuable and helpful information was given in a paper on "Reports," read by Mr. J. D. Taylor, M.I.E.E., on 21st December. The paper was illustrated by lantern slides. These showed certain fundamentals applicable in all cases of report writing. Specimen cases also were illustrated and it was perfectly clear that, by proceeding along the lines indicated, much of the difficulty in preparing satisfactory reports would be overcome, and the number of papers referred back for additional information minimised. The paper was illumined by humorous and expressive quotations from various reports. A spirited and instructive discussion followed.

On the 18th Januray, Mr. W. B. Crompton, of the Engineer-in-Chief's Office, read a paper on " Local Line Plant Economics " by Mr. H. Kitchen, M.I.E.E. The paper, which has been described elsewhere in the Journal, was thoroughly appreciated and the many points raised in an interesting discussion were ably replied to by the lecturer.

The fourth meeting was held on 22nd February, when a paper on " Scientific Organisation and the Post Office Engineering Department " was presented by Capt. F. G. C. Baldwin, Assistant Superintending Engineer, Newcastle-on-Tyne. A copy of the paper had been supplied to each member and was taken as read. A general survey of the ground covered by the paper, with explanations of an excellent series of lantern slides, were given by Capt. Baldwin, and a full discussion followed. A brief description of the paper has already appeared in the Journal. The arrangement of inviting a lecturer from a neighbouring Centre proved an admirable one and will, it is hoped, be repeated.

Mr. J. M. Couch, A.M.I.E.E., contributed a paper on " Secondary Cell Installations " at a meeting on 15th March, 1927. Mr. Couch is always a popular lecturer and his highly interesting and instructive paper was closely followed and gave rise to a good discussion.

A hearty vote of thanks was accorded all the lecturers.

SCOTLAND WEST CENTRE.

The fifth and last meeting for Session 1926-27 was held in the Royal Technical College, Glasgow, on Monday, 7th March. Before taking the routine business the Chairman referred to the loss sustained by the Local Centre in the death of Mr. D. W. Watson, Executive Engineer, who died as a result of injuries received in a motoring accident.

The lecturer for the day was Mr. T. Hetherington, A.M.I.E.E., who took for his subject " Growth of the Trunk System." The lecture was a review of the steps by which the trunk system had advanced from the earliest stage, when overhead construction was compulsory, to the present time with the longest circuits wholly underground.

Beginning with tables of the growth year by year in the number of trunk calls from 1896 onwards, and the corresponding yearly increase in the number of trunk circuits required to meet the public demand, the lecturer showed, chiefly by data relating to Scotland West District, how routes rapidly became congested owing to the necessity of overhead construction being adhered to, and the need which arose for some method of relief being forthcoming. This relief came when loading extended the distance over which speech was possible on underground circuits. The development of tandem schemes linking up the larger towns in an area was then touched on, and the Scotland West schemes were shown in detail. Finally, the lecturer referred to the advance which the thermionic valve made possible and gave details of the London-Glasgow cable to illustrate the progress made.

There was a very good attendance of members and a good discussion followed.

H.C.M.

BOOK REVIEWS.

" Electric Switch and Controlling Gear." Charles C. Garrard, Ph.D., M.I.E.E., A.M.I.E.E. Third Edition. Ernest Benn, Ltd. 63/- net.

In view of the rapid development and increasing variety of modern switch and control gear Engineers will welcome the third and up-to-date edition of this work; it is impossible for others than specialists to keep in touch with all the latest designs and applications of electric switch and control gears and this work should therefore prove of special value as a standard book of reference to electric power engineers.

The first chapter naturally deals with materials and manufacturing methods; in the 2nd chapter 100 pages are devoted to what is the most important piece of apparatus on a switchboard, namely, that required for making and breaking electric circuits, starting from the ordinary knife switch up to the latest type of oil circuit breaker. The next two chapters are perhaps the most valuable and deal exhaustively with the prevention of dangerous currents and with apparatus for regulating the amount of current. The selection of suitable protective apparatus for use on a Power system is perhaps one of the most difficult problems to be faced by the Engineer, and the information given should be of considerable value for this purpose.

Starting and controlling apparatus are dealt with in the next chapter and then come the complete switchboards; here, in view of the preeminence of British manufacturers in the iron-clad type of switchgear, we should have expected more information on this subject. The question of supervisory control or automatic control of substations is dismissed in a few paragraphs, although this subject has now reached an important stage of development and is being extensively adopted.

The question of apparatus protecting electrical machinery against abnormal electrical conditions is adequately dealt with in the final chapter.

Ten Appendices follow, but as these only contain information which is usually to be found in Books of Reference, it is suggested that the space might have been more usefully occupied by further information on the development of Ironclad Switchgear and Automatic Substation control.

E.H.W.

"The Engineers Year Book, 1927," compiled and edited by H. R. Kempe, M.Inst.C.E., M.I.Mech.E., M.I.E.E., and W. Hanneford Smith, F.R.S.E., Assoc.Inst.C.E., M.Inst.Met. Crosby Lockwood & Son. 3101 pp. 30/- net.

The first edition of the Engineers' Year Book issued in 1894 was compiled as a standard Book of Reference for the Engineer in the practical work of his calling and included Civil, Mechanical, Marine, Electrical and Mine Engineering. Revisions and additions to succeeding editions have increased the size from 570 pages to 2900 pages of subject matter, the principal new and re-written sections in the 1927 edition being those relating to Automobiles, Aero Engines, Refrigeration and Lighting.

The necessarily voluminous nature of this work, covering as it does almost every subject connected with Engineering, avoids the difficulties which might otherwise be met with in the facilities for ready reference by its excellent subdivision into appropriate sections and the complete index of more than 70 pages.

Somewhat unexpectedly, having regard to the special knowledge and experience of the Editor-in-Chief, the subject of Communication Engineering has had less expansion in the space devoted to it than other branches of Engineering. The data and subject matter of this section might well be amplified to cover the ground of recent developments in Telegraphy, Telephony and Radio Engineering.

The production, printing and general arrangement of the volume is maintained at its usual high standard and it fully maintains its usefulness as a work of reference for the Engineer who has occasion for authoritative information outside his usual range of subjects.

A.S.A.

"Questions and Solutions in Telegraphy and Telephony, Grade I. Examinations." H. P. Few. 350 pp. Price 6/6.

This book supplies answers to the City & Guilds examinations in Grade I. from 1904 till 1919 inclusive and for 1925, also some questions and answers in the written and oral examinations for Overseers and an index. The answers have been fully and carefully dealt with, as one would expect from our late colleague who was himself a Silver Medallist and First-class Honoursman in Telephony and a certificated Teacher of the City & Guilds of London Institute. He is also the author of a book on "Elementary Determinants for Electrical Engineers." Our old friend died in September of last year, but this book will serve to keep him in mind for many a year. It should be invaluable for all students preparing for the Grade I. examination, not only for the information supplied but also as a model for the way in which questions should be answered, showing the examiner that the question is thoroughly understood and that the answer has not been unduly prolonged with details not required.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Bailey, W. J.	Assistant Staff Engineer, E.-in-C.O.	Staff Engineer, E.-in-C.O.	23-3-27
Thompson, H. S.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	23-3-27
Markwick, J. J.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	19-3-27
Cowling, G.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	28-2-27
O'dell, G. F.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	23-2-27
Balcombe, R. C.	Assistant Engineer, S. Lancs. Dist.	Executive Engineer, N. West District.	19-4-27
McClarence, F.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	7-4-27
Phillips, A. C.	Assistant Engineer, S. West District.	Executive Engineer, S.E. District.	To be fixed later.
Lane, W. H.	Assistant Engineer, S. Wales District.	Executive Engineer, N. West District.	,,
Eason, A. B.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	7-6-27
Beach, W. R.	Probationary Assistant Engineer.	Assistant Engineer, E.-in-C.O	1-4-27
Straw, J. G.	,,	Assistant Engineer, E.-in-C.O	,,
Tyson, W. R.	,,	Assistant Engineer, E.-in-C.O	,,
Jones, H. C.	,,	Assistant Engineer, E.-in-C.O	,,
Williams, H.	,,	Assistant Engineer, E.-in-C.O	,,
Tufnail, M. E.	,,	Assistant Engineer, E.-in-C.O	,,
Baines, J.	,,	Assistant Engineer, E.-in-C.O	,,
Hollinghurst, F.	,,	Assistant Engineer, E.-in-C.O.	,,
Edwards, J. J.	,,	Assistant Engineer, N.E. District.	,,
Cox, H. E.	,,	Assistant Engineer, E.-in-C.O	,,
Morrill, A. E.	,,	Assistant Engineer, London District.	,,
Wright, F. V.	,,	Assistant Engineer, S.W. District.	6-4-27
Cooper, M. C.	,,	Assistant Engineer, E.-in-C.O	1-4-27
Reading, J.	,,	Assistant Engineer, E.-in-C.O	,,
Palmer, R. W.	,,	Assistant Engineer, E.-in-C.O	,,
Perkins, B. H.	Inspector, S. Mid. District.	Chief Inspector, S. Mid. District.	14-4-27
Young, W.	Inspector, S. East District.	Chief Inspector, S. East District.	25-12-26
Myers, W. H.	Inspector, S. Lancs. District.	Chief Inspector, S. Lancs. District.	2-1-27
Mealing, W. B.	Inspector, N.E. District.	Chief Inspector, N.E. District.	10-4-27
Kilgour, A.	Inspector, Scot. West District.	Chief Inspector, Scot. West District.	To be fixed later.
Edwards, J. R.	Inspector, N. West District.	Chief Inspector, Northern District.	15-5-27
Green, W.	Inspector, Eastern District.	Chief Inspector, S. East District.	To be fixed later.
Haseley, S. H.	S.W. Class I., S.E. District.	Inspector, S. East District.	1-10-26
Halls, A. N.	S.W. Class I., S.E. District.	Inspector, S. East District.	9-8-26
Jolliffe, A. P.	S.W. Class I., S.E. District.	Inspector, S. East District.	25-4-26
Veneer, A. G.	S.W. Class I., S.E. District.	Inspector, S. East District.	4-10-26
Miles, A.	S.W. Class I., S.E. District.	Inspector, S. East District.	22-1-27
Fox, L. A.	S.W. Class I., Testing Branch.	Inspector, Testing Branch.	24-11-26
Wells, H. G.	S.W. Class II., London District.	Inspector, London District.	1-10-26
Bazley, W.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Pollard, A. C.	S.W. Class I., London District.	Inspector, London District.	12-1-27
Burnell, C. L.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Weinel, C. F. G.	S.W. Class I., London District.	Inspector, London District.	8-1-27
Town, A.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Hopgood, C. L.	S. W. Class II., London District.	Inspector, London District.	16-3-27
Chasmar, W. P.	S. W. Class II., London District.	Inspector, London District.	1-1-27
Roberts, H. T.	S. W. Class II., London District.	Inspector, London District.	30-1-27
Brinkley, E.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-3-26
Harben, A. E.	S. W. Class I., Eastern District.	Inspector, Eastern District.	26-1-27
Ware, F.	S. W. Class I., Eastern District.	Inspector, Eastern District.	20-1-27
Taylor, W.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-3-26
Short, C. C.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-1-27
Waugh, J.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	26-3-27
Henderson, R. M.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	6-1-26
Kelt, W.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	16-8-26
Hall, H.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	4-8-25
Sherriffs, J.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	11-4-27
Goodfellow, R.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	11-4-27
Wilkinson, H. T.	S.W. Class I., N. East District.	Inspector, N.E. District.	25-7-26
Marshall, F. E.	S.W. Class I., N. East District.	Inspector, N.E. District.	27-5-27
Fender, J. D.	S.W. Class I., Northern District.	Inspector, Northern District.	5-2-27
Blackie, J.	S.W. Class I., Northern District.	Inspector, Northern District.	13-2-27
Watt, A.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27
Blaney, H. J.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Morrow, J. G. M.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27
Steedman, C. A....	S.W. Class I., S. Mid. District.	Inspector, S. Mid. District	7-6-26
Curling, T.	S.W. Class II., London District.	Inspector, London District.	27-2-27
Skeoch, W.	S.W. Class I., Scot. West District.	Inspector, Scot. West District.	25-10-26
Godfrey, A. E.	S.W. Class I., London District.	Inspector, London District.	27-3-27
Masters, F. R.	S.W. Class I., London District.	Inspector, London District.	9-4-27
Faulkner, F. G.	S.W. Class I., London District.	Inspector, London District.	9-3-27
Collerson, W. J. Y.	S.W. Class I., London District.	Inspector, London District.	19-4-27
Walker, A. G.	S.W. Class I., Eastern District.	Inspector, Eastern District.	15-2-27
Pettet, V. D.	S.W. Class I., Eastern District.	Inspector, Eastern District.	12-3-27
Francis, A. R.	S.W. Class I., Met. Power District.	Inspector, Met. Power District.	19-4-27
Lyddall, A. G.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	25-8-26
King, W. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	4-9-26
Roche, J. J.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	23-8-26
Abbott, G. A. O.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Sawyer, R. W.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	28-8-26
Waters, S. A.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Hull, S. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	23-8-26
Magnusson, L. E.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Mills, A. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Winch, B.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	26-8-26
Rudham, J.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	28-8-26
Young, J. S.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	19-10-26
Lague, J. H.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	25-8-26
Goman, L. V.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Jenkinson, H.	S.C. & T.	Repeater Officer Class II., N. Wa. District.	16-9-26
Florance, F. V.	S.C. & T.	Repeater Officer Class II., S. Wa. District.	16-9-26
Anderson, A. G.	S.C. & T.	Repeater Officer Class II., N. Wa. District.	16-9-26
Halliday, W. G.	S.C. & T.	Repeater Officer Class II., Eastern District.	14-10-26

APPOINTMENTS.

Name.	Grade.	District.	Date.
Beard, A. T. J.	Probationary Assistant Engineer.	London.	18-3-27
Fisher, H. C.	Fourth Engineer.	H.M.T.S. Monarch.	25-2-27
Stacey, P. A.	Probationary Inspector.	E.-in-C.O	6-3-27
Reed, T. F.	,,	S.W.	27-4-27
Waters, H. S.	,,	S.E.	27-4-27
Howarth, H.	,,	S. Lancs.	—
Chandler, R. W.	,,	E.-in-C.O	16-5-27
Bavin, A. E.	,,	Testing Branch.	3-3-27
Buck, G. L. N.	,,	,,	29-4-27
Styles, G. E.	,,	,,	19-4-27

DEATH.

Name.	District.	Grade.	Date.
Winny, W. H.	E.-in-C.O.	Assistant Staff Engineer.	31-5-27

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
Lockhart, J.	Executive Engineer.	N.W. District.	Scot. W. District.	To be fixed later.
Cheetham, W. B. ...	Assistant Engineer.	N.W. District.	Eastern District.	
Stratton, J.	Proby. Asst. Engineer.	London District.	E.-in-C.O.	23-5-27

RETIREMENTS.

Name.	District.	Grade.	Date.
Wicker, G. J. M.	N. Wales.	Chief Inspector (unestablished)	7-4-27
Martin, W.	Met. Power.	Chief Inspector	30-4-27
Naylor, F. D.	S. Lancs.	Inspector (Unestablished).	3-5-27
Colyer, E. J.	London.	Inspector.	31-5-27
Hart, H.	,,	,,	31-5-27

CLERICAL ESTABLISHMENT.

TRANSFERS.

Name.	Grade.	From.	To.	Date.
Corney, P. A.	H.C.O.	S.W. District.	S.M. District.	24-4-27
McMullin, T.	,,	N. Ireland.	S.W. District.	3-5-27

DEATH.

Name.	Grade.	Cause.	Date.
Payne, C. W. H....	H.C.O.	Death.	9-3-27

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838	Prize Essays. Competition 1926-7.	
839	Treatise on Probability	J. M. Keynes.
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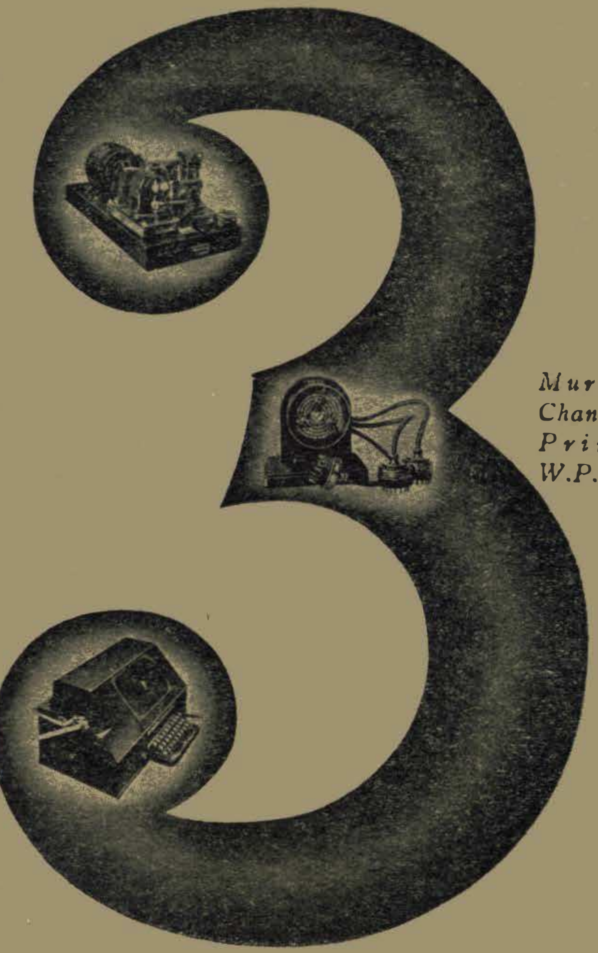

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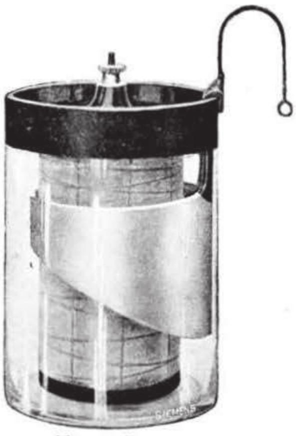

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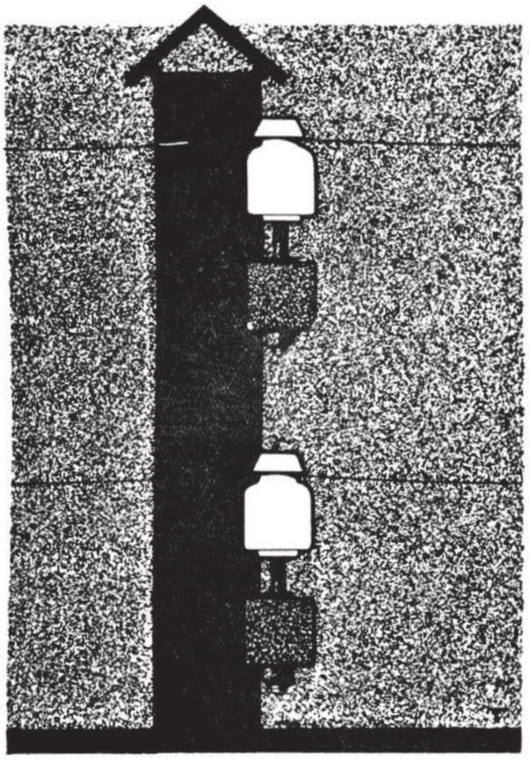

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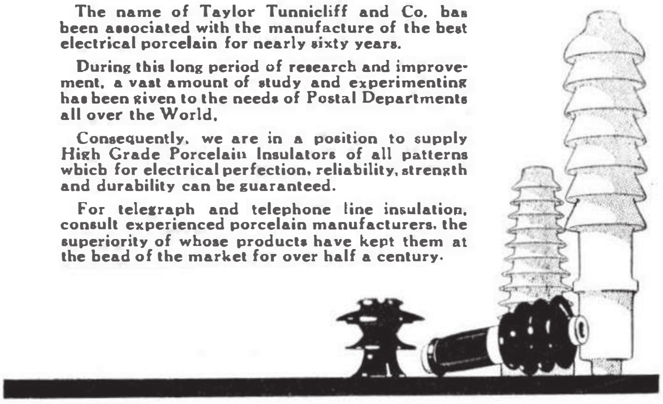

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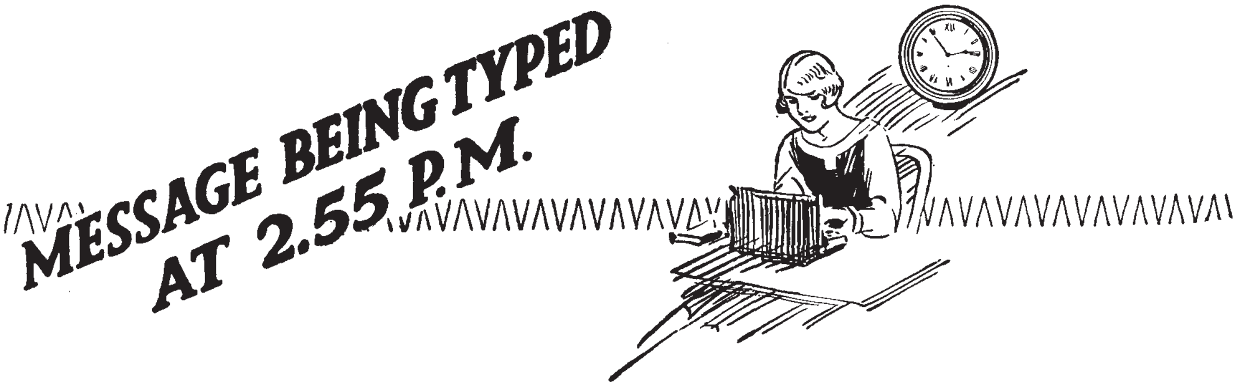

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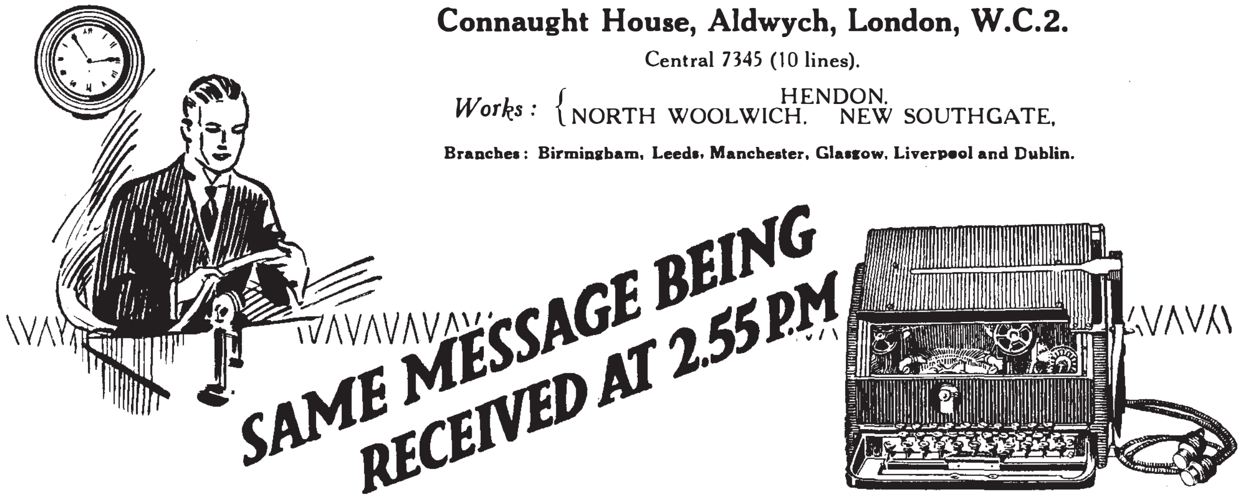


THE
Post Office Electrical Engineers' Journal

THE PASSING OF THE BAUDOT SEXTUPLE DUPLEX.

A. C. Booth.

THE last few months have seen the replacement of the Baudot Sextuple Duplex sets which have worked so well on two circuits between London and Birmingham for the last twelve years. On these two circuits were obtained some very noticeable results, which are hardly likely to be excelled or even equalled by any other system. On the 5th February, 1915, one of them dealt with more than 8,000 messages in the day of about 12 hours, and passed 849 messages in one hour. For this reason it is a great pity to see such useful apparatus withdrawn from the service. It has, however, more than justified its installation as it was brought into use at a time when there was a rather strong opposition to the introduction of the Duplex Baudot system, and there was considerable difficulty in keeping the Quadruple Baudot sets in service. The Sextuple Duplex was therefore installed and given close supervision for a month. The results obtained were excellent and from that time forward there was little or no trouble with any Quadruple Duplex set. Although the Sextuple sets were fitted rather for demonstration purposes, the results obtained were so good that they were allowed to remain in use.

The reason for the change that has now been made is due partly to the reduction in the amount of Telegraph traffic to be dealt with on this route, and partly to the economy arising from the use of Keyboard Perforators, which enable a higher speed of working to be obtained. The London-Birmingham service is now given by two circuits, each equipped with four duplex channels fitted with Keyboard Perforators and Transmitters, and each working at a speed of 35 words a minute and giving a maximum output of 140 words a minute each way on each circuit instead of 180, thus saving 4 operators at each end.

The new sets are not Quadruple Duplex but Quintuple Duplex with the fifth pair of channels available for use as an extension to another circuit. It is proposed to make an extension to the fifth pair of channels on the London-Brighton Quintuple Duplex circuit, which is also working with Keyboard Perforators at 35 words a minute.

At present the fifth channel on the London-Birmingham circuit is being used by the Dirigeurs for speaking purposes, utilising the spare receiving instrument and an ordinary 5-key Baudot sender at each end. No difficulty has been experienced in operating the 5-key sender at the higher speed of 210 cadences instead of the usual 180 a minute.

THE TELEPHONE AND TELEGRAPH SYSTEM OF NEW DELHI.

N. F. FROME, B.SC., A.D.E., TELEGRAPHS.

LOCAL TELEPHONE SYSTEM.—The new capital city of India at Delhi, now nearing completion, has been built to the south of the old city and contains the large buildings of the Government Secretariats, Government House and the Council Chamber, as well as residential and shop areas. The complete telephone system for the whole of the new city was designed in 1923 and installed as the city was being built.

To carry the New Delhi telephone load it was decided that a main automatic exchange should be installed in the new city, and that a second exchange of a similar type should replace the manual C.B. exchanges which had hitherto served the old city and temporary government buildings. This scheme has been carried out; Raisina exchange in New Delhi, Lothian exchange in the old city and a third small exchange at New Cantonments, five miles away, now comprise the local exchange system.

Local Exchanges.—Raisina exchange is of the automatic switch type supplied by the Peel Conner Telephone Works, with 1500 lines equipped and with an ultimate capacity of 3000 lines. It has been installed in the North Block of the Secretariat buildings and was brought into service in September 1925. The distribution frames and switch bays occupy two large rooms on the ground floor above the power, cable, and battery rooms in the basement.

A feature of the exchange construction to deal with local conditions is the provision of double doors and a special dust trap ventilating system in the switch room, which serve as a protection against the severe dust storms often experienced during the hot weather. The switch bays are in addition enclosed in dust-proof cabinets.

An exceptional requirement, probably almost unique in telephone practice, results from the Headquarters of the Government of India moving to the hills for the hot weather. As a result of this, the number of subscribers in Raisina exchange suddenly increases by about 300 % every year in October and falls away again in April. Coupled with this is the exceptional use made of the telephone. With the advent of the Government to New Delhi, with their office establishments in several buildings, the telephone is invaluable, as will be seen from the cold weather busy-hour calling rate, which is approximately 1.7 calls per subscriber. On the whole, considering the difficulties which have to be encountered, complaints are very few and the exchanges deal very satisfactorily with the volume of traffic.

Lothian exchange, 4½ miles from Raisina, in the old city is of the same type as Raisina and is equipped for 1500 lines, 3000 lines ultimate. The exchange is housed in a building built for the purpose and deals with the commercial and residential areas in Old Delhi, most of the subscribers being Indians.

These two main exchanges work interconnected, Raisina working on the two, three and four thousand, and Lothian on the five, six and seven thousand groups.

Features of interest in the exchange operation are that the switches are required to work over a temperature range of from about 100° F. in the hot weather to 40° F. in the cold weather, whilst, during the rainy season, the humidity rises from 25% to 85%. During the hot weather, as is usual with automatic exchanges in India, to avoid expansion troubles it is necessary to make provision for keeping the switchroom at as low a temperature as possible.

No dialling tone is used, and a " disconnect " tone interrupted 120 times per minute is used for " busy " services.

The provision of a good exchange earth is always a matter of difficulty in India, and especially so in New Delhi where the New City has been built on the rocky Ridge of historic fame (the rocky nature of the ground can be seen in Fig. 2). Raisina exchange has therefore been earthed to a near-by well in which there is a permanent supply of water.

The third exchange of the system at New Cantonment is a Relay Automatic P.A.B.X. plant, converted for use as a public exchange, with 30 lines equipped and 60 lines ultimate.

This is connected by cable and overhead junctions to Raisina and works into the Delhi system by the use of an initial digit-8.

In addition, it may be remarked that all the exchanges of New Delhi work unattended at night, whilst the New Cantonment exchange is worked entirely unattended, with only periodical maintenance visits.

Before the opening of the new telephone system in September 1925, steps were taken to educate the public in the use of automatic telephones. Instruction tents were erected in various parts of the old city and fitted with instruments to enable interested persons to call from one tent to another *via* the auto exchange. This was found to be a great help in bringing the system into service and proved a big factor in enabling a very successful cut over to automatic working to be made. In service the automatic exchange system has proved very successful and it appears to be particularly suitable for giving telephone service in the conditions met with in India, and Indian subscribers greatly appreciate its rapidity and accuracy.

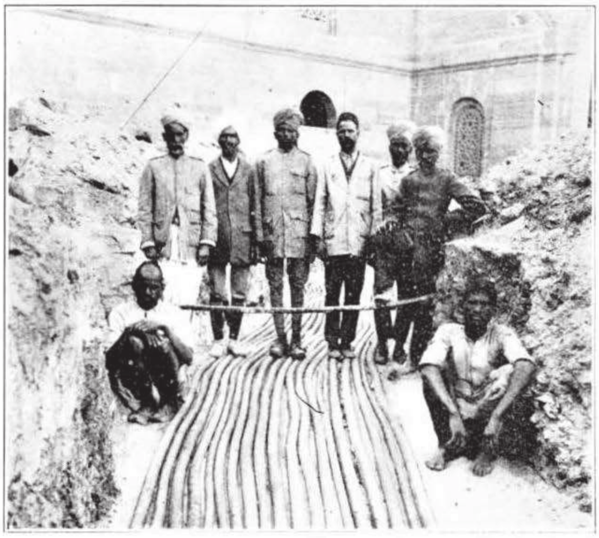


FIG. 1.—TELEPHONE CABLES.

Local Distribution System.—In the new city, the distribution from the exchange is, with the exception of the final distributing points, carried entirely underground in armoured L.S.P.C. 10-lbs. conductor cables. The cables (Figs. 1 and 2) are laid direct in the ground but, however, surrounded with a bed of river sand to form some protection against the impregnated soil. Joints are enclosed in bitumen-filled brick chambers and marked above ground by special stones indicating the cable number and position of the joint. The final distribution poles are of the usual Indian Hamilton steel tube pattern and are fitted with fuse and lightning arrestor protection against the heavy thunderstorms experienced in India. It may be interesting to mention here that with the Departmental standard pattern of Hamilton tubes posts can be built from 16 feet to 264 feet high. Of the series of tubes, the first five sections, each 8 feet in length, are tapered and made of rolled steel sheeting. These tubes are so designed that the lower portion of each tube is a driving fit on to the upper portion of the next in the series. The subsequent sections are from 8 to 10 feet in length and are flanged to admit of their being bolted together.

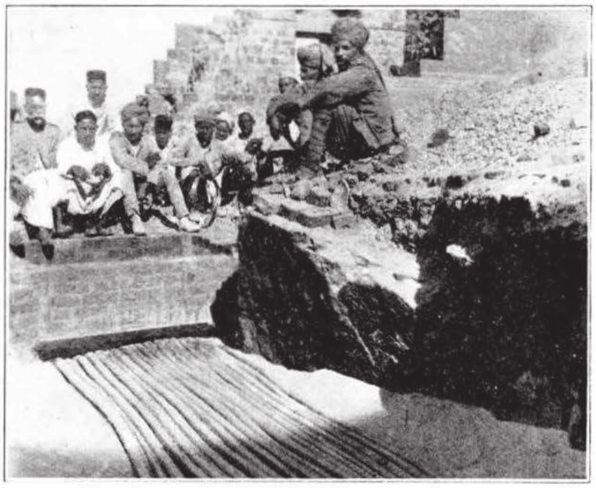


FIG. 2.—TELEPHONE CABLES.

In the new city the final overhead lines in most cases radiate from circular pole brackets to the surrounding subscribers' premises.

The large government buildings of New Delhi have been fitted with an extensive system of block wiring distribution. L.S.P.C. cable is used from the exchange to the distribution boxes and V.I.R. pairs carried in insulated steel conduits provide the leads to the telephone points, the cables and conduits being installed in a trough system used also for the electric light and power distribution. 1040 subscribers will be provided for in this manner. In addition to the telephones, the wiring system in the large buildings is used to provide circuits for a large electric clock system and for the operation of automatic division bells in the Legislative Council Chambers. It is interesting to note that nearly 10 miles of conduit have been installed in the three main buildings.

The cable scheme has, of course, to provide for the annual load variation and in addition is designed to meet any heavy demand arising from future durbars and large Government functions. The New City cable network contains roughly 25,000 miles of conductors.

Long Distance System.—The trunk exchange and central telegraph office in New Delhi are located in the main Telegraph Department buildings a mile or so to the north of the main government buildings.

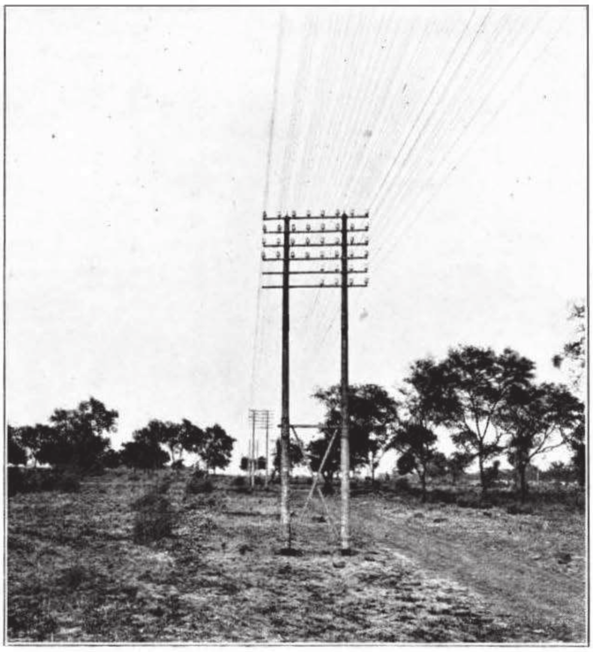


FIG. 3.—TRUNK LINE.

The only large overhead line allowed to be erected in the new city terminates at the telegraph buildings and carries the trunk and long distance telegraph lines on open wires to the office (Fig. 3). Shorter and less important lines are brought into the city in underground cables.

Trunk Exchange.—The trunk exchange switchboard (Fig. 4), also supplied by the Peel Conner Telephone Works, contains the trunk operating positions and also the record and enquiry positions for the local telephone system. The board is of a cordless type and has been modified to work on an automatic selection scheme, using relay equipment of the Peel-Conner North Electric variety. Present equipment provides for 20 trunk lines and 10 outgoing junctions to each main local exchange, with an ultimate capacity of 40 trunks without requiring switchboard extension.

Central Telegraph Office.—The telegraph plant fitted in the large Central Telegraph Office (Fig. 5) includes closed circuit, Morse duplex, Baudot and Murray machine telegraphs. The office has been designed in accordance with American practice, the Morse circuit equipment actually fitted on the office tables being confined to keys and sounders only, with a push button alarm communicating with the test room which contains the remaining apparatus.

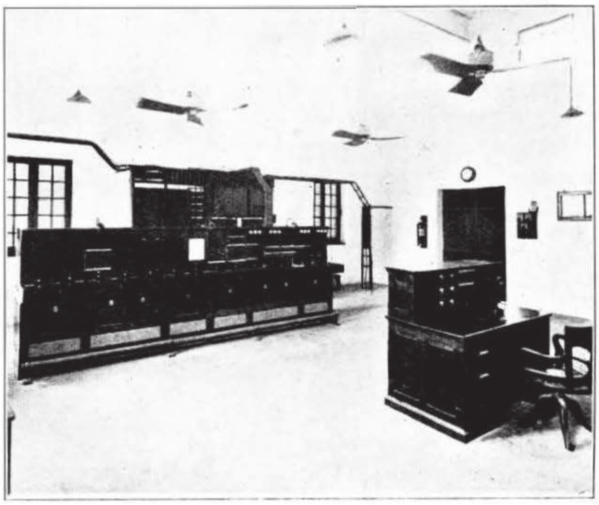


FIG. 4.—TRUNK EXCHANGE, NEW DELHI.

The office wiring is carried to the tables in troughing.

The lighting, fan and heating installation of the office and the telegraph buildings was carried out, as usual, departmentally. Insulated conduit is used to carry the wiring. In the telegraph office, semi-indirect lighting has been employed and when the office is full forty-four 200-watt light points and 88 fans will be in service. Some 24 K.W. of heating current will be required during the cold weather.

Test Room.—This room, situated between the trunk exchange and the telegraph office, is equipped for testing and controlling all trunk line and telegraph apparatus. It contains the cable terminations, distributing frames, trunk and telegraph test switchboards, Morse board, duplex apparatus, battery supplies and telephone repeaters. Most of the apparatus of the room was designed and built locally (Figs. **6** and **7**).

The trunk test board is of the break-jack type and is equipped for composite trunk line working. The telegraph test board and Morse board are also of the break-jack type, " patch " cords and jumper fields providing cross-connecting facilities and flexibility of apparatus. The circuit and jack systems are so arranged that any duplex set can work on any line or on any position in the telegraph office, whilst additional facilities are available, such as the " patching " together of any two duplex sets to form a duplex repeater. Small local telegraph offices in the Delhi area which work duplex to distant stations also use the central office duplex sets, the local office being equipped only with key and sounder. A feature of this arrangement is the saving of batteries and set maintenance and the consequent higher standard of working resulting from the better control which can be exercised over the sets.

FIG. **5**.—CENTRAL TELEGRAPH OFFICE, NEW DELHI.
Photo taken at night.
Shows arrangement of lights, fans and tables.

From the experience gained of the test room working it is now contemplated to work the Baudot and Murray sets on the same principle, the office instrument tables being only fitted with the keyboards and printers, and it is anticipated that the better control obtainable with this system will greatly increase the efficiency of the machine telegraph operation.

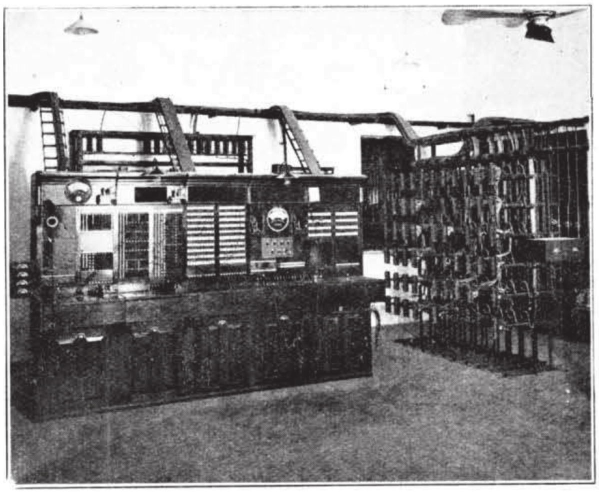


FIG. **6**.—TEST ROOM, NEW DELHI.
Shows Test and Morse Board, incoming Cables, M.D.F. and Composite Apparatus Rack.

In the test room, all battery taps are protected with resistances and heat coils on a battery tap rack; other racks carry the composite sets, composite ringers and telephone repeater balancing networks. Battery power is also supplied to the Railway and Irrigation Canal Telegraph systems from the Central Office plant and has resulted in considerable saving, as batteries previously maintained by the department in these offices have been eliminated.

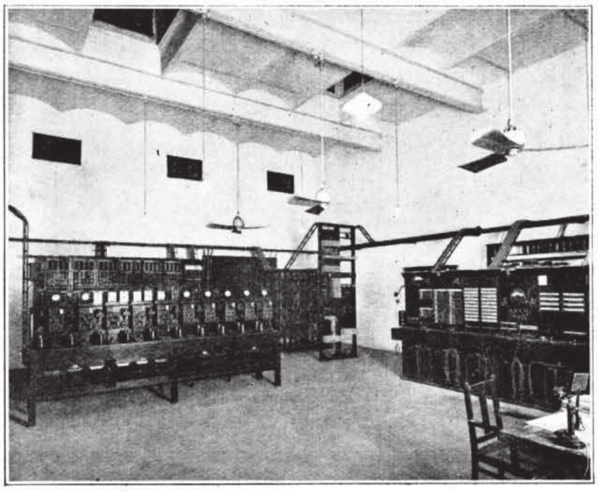


FIG. **7**.—TEST ROOM, NEW DELHI.
Shows Test and Morse Board, Duplex Sets, Cord Circuit Repeaters, Battery Tap Rack and I.D.F.

Such concentration of apparatus in one room under the control of a technical staff, apart from the telegraph office and trunk exchange staff, is a new departure in Indian practice and from the experience which has already been gained it appears to be a long stride forward in the direction of improving facilities for telegraphic communication in India, and when other offices have been fitted in a similar manner even further advantages will be derived from this new system.

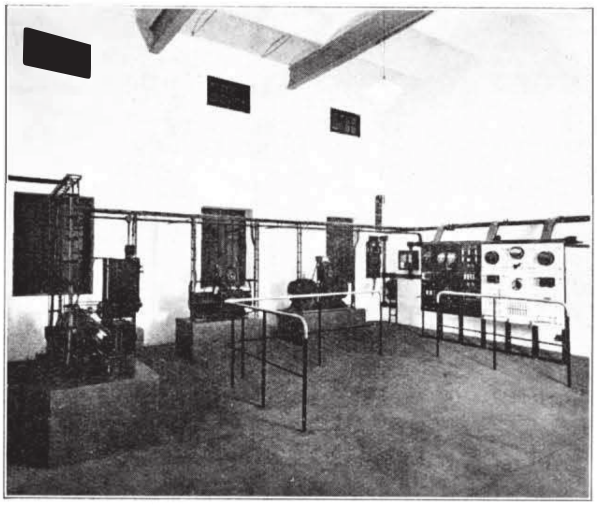


Fig. 8.—Power Room, C.T.O., New Delhi. Motor-generators and Switchboard.

The power room of the main telegraph building is shown in Fig. 8 and contains the motor-generator sets for battery charging, control switchboards and 440-volt D.C. power supply. The telegraph switchboard fittings include a battery-reversing switch of a radial pattern and the charging and discharge switches, fuses, etc., for the telegraph and Baudot motor batteries. On the telephone panels are mounted the switchgear and instruments of trunk exchange batteries and repeater batteries.

It will of course be realised that in this short description it is impossible to enter into much detail of the design and circuits of the telegraph and telephone plant or the special difficulties often met with under Indian conditions. It is hoped, however, that enough has been said to show that the Telegraph Department has attempted to provide telegraph and telephone facilities worthy of the new Capital City of the Indian Empire.

FEDERATED MALAY STATES.

REPORT ON THE POSTS AND TELEGRAPHS DEPARTMENT FOR THE YEAR 1926.

THE following extracts from the report of the Secretary for Postal Affairs, Straits Settlements and Federated Malay States, may prove of interest:—

Telegraphs.—During the year 465,516 telegrams were despatched and 509,522 were delivered, increases of 52,004 and 58,004, respectively. The revenue derived from telegrams was $455,579. The revenue shows an increase of $113,562 as compared with 1925. The value of telegrams sent free of charge for other Government departments was $51,337, an increase of $7,366.

Telephones.—The number of subscribers to the telephone exchange on the 31st December was 3,450, an unprecedented increase of 623, *i.e.*, 22 per cent. during the year. In addition there were 1,598 extension lines, extension bells, private circuits, private bell or alarm circuits and tell-tale clock circuits maintained by the department, as compared with 1,401 in 1925.

The revenue derived from telephones was $904,511, an increase of $207,729 or nearly 30 per cent. over 1925. The trunk revenue amounted to $277,253, 30 and 84 per cent. higher than the 1925 and 1924 figures, respectively.

Five new public telephone exchanges were opened. Including the sub-exchange at Maxwell's Hill there are now 42 public exchanges in the Federated Malay States.

Public call boxes are available at 80 post offices.

On the 31st December there were 70 applicants awaiting connection to the telephone system, all very recent applications except for one or two long circuits.

The resources of the department were again strained to the utmost in its efforts to meet the demand, and there were periods of anxiety as to whether equipment could be obtained from England in time to meet public requirements. The coal strike seriously delayed delivery of materials and equipment, and as a result at the end of the year many items on order from the Crown Agents were still outstanding.

Traffic records taken quarterly during the year show the average number of calls per day direct exchange line to have been 12.3, an increase of 11.8 per cent. on 1925. It is estimated that the total number of calls originated in 1926 was approximately 11,400,000, of which 210,000 were junction and 1,200,000 trunk calls. The average number of originated calls handled per day was approximately 39,000, of which 720 were junction and 4,100 trunk calls.

A development study of the Kuala Lumpur Exchange Area has, amongst other preliminary work, been completed during the year. Traffic investigations relative to the proposed Malayan Trunk Scheme, which is also referred to under Engineering, have been delayed by pressure of other work arising from the rapid growth of the system during the year under review.

The exchanges at Kuala Kangsar, Kulala Lipis and Parit were temporarily closed for a few days at the end of the year on account of the floods.

During the year the subject of " party line " telephones has been pursued and a promising adaptation of machine switching equipment 's under consideration with a view to trial of the system in the Federated Malay States.

The question of utilising wireless transmission as a telephone link between exchanges to be established on the east coast anu the main trunk system has been actively followed up during the year and comparisons of the costs of the various alternatives proposed are now in hand.

Engineering.—On 31st December there were 2,618 miles of telegraph and telephone lines and 19,861 miles of overhead wire in the Federated Malay States, of which 16,872 miles were telephone wires. In addition there were 79 miles of underground cables containing 7,774 miles of wire single line. These figures do not include the poles and wires maintained by the Railway Department for their own use. The Posts and Telegraphs Department also owns and maintains 122 miles of line and 422 miles of wire in Johore. It also maintained in addition to its own lines 1½ miles of pole line for Kedah, 339 miles of wire for Johore, and 23 miles of pole line in Dindings.

The work of laying underground cables was in progress in Kuala Lumpur throughout the year, partly replacement of faulty cables and partly additional cable for development. New underground cables were also laid at Bahua, Ipoh, Kampar, Kuala Kangsar, Kuala Kubu, Kuala Lipis, Port Swettenham, Basa, Raub, Rawang, Rembau, Semenyih, Sitiawan, Taiping and Teluk Anson.

Much damage was done by the serious floods experienced at the end of December to telegraph and telephone pole lines and plant in the valley of the Perak River and throughout Pahang. Kuala Lumpur exchange building was again flooded but the precautions taken during the year proved adequate to prevent serious interference. The exchange was without external electric power supply for several days, during which period batteries were kept charged by means of a petrol motor engine taken from a condemned motor mail van. At Ipoh the only telephone damage was the submersion of a small quantity of subscribers' apparatus. At Kuala Kangsar the water rose to the first floor of the post office and submerged the telephone exchange entirely. All subscribers' apparatus in the town was also submerged, and nearly all the overhead wires were broken down. Most of the underground cables withstood the flood and the exchange system was in consequence speedily restored though, apart from the cables, practically the whole of the plant had to be renewed. At Parit exchange the switchboard was saved by being cut adrift and removed to the first floor of the post office. The main telegraph and telephone route from Selangor to Pahang *via* the Gap was seriously damaged by landslides and falling trees. Communication as far as Raub was, however, rapidly restored by the Kuala Kubu and Raub district staffs, who worked steadily in spite of pouring rains and transport difficulties. Long sections of route were washed away between Raub and Lipis and Raub and Kuantan, and between Kuantan and Pekan.

Reports and estimates in connection with the Malayan Trunk Telephone (Cable) Scheme were received from the Consulting Engineers and the British Post Office towards the end of the year. The estimates are considerably in excess of the original estimate and the scheme is still under consideration.

Shortage of technically trained Asiatic staff is still acute.

Wireless.—Forty-nine temporary licences for the use of wireless receiving apparatus were issued during the year and one experimental transmitting licence.

The British official news broadcast from the British wireless station near Rugby is received at Penang wireless station, retransmitted from Penang by land line, and supplied to the local newspapers on payment of a monthly fee averaged roughly 20,000 words a month.

Workshop.—The workshop has continued to be of great service to the department and there was a considerable increase in the volume of new work undertaken. The output was satisfactory both in quality and quantity. A further reduction in on-costs has been effected.

Stores Branch.—The number of different items stocked was 3,492, an increase of 413 items. The value of stores issued and received in 1926 was $2,183,387, compared with $1,433,000 in 1925.

Under Appointments it is noted that Mr. C. G. Cadman, Telegraph Engineer, Posts and Telegraphs, Federated Malay States, has been appointed to the post of Engineer-in-Chief, Posts and Telegraphs, Straits Settlements and Federated Malay States.

The following table indicates the growth of the system from 1906:—

TELEGRAPH AND TELEPHONE SYSTEM.

Year.	Length of overhead line. Miles.	Length of overhead wire. Miles.	Length of under-ground cables. Miles.	Length of wire single line in cables. Miles.
1906 ...	1,381	2,509		
1916 ...	2,210	10,461	26½	2,418
1926 ...	2,618	19,861	79	7,774

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1927.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
545,012	539	4,172	52,166	178	London	23,393	61,243	2,009,491	129,671
67,847	1,879	21,704	62,554	1,492	S. East	3,949	42,499	162,166	14,656
72,064	4,380	29,838	50,922	2,423	S. West	16,426	10,396	129,311	54,955
56,524	5,802	34,385	49,138	5,024	Eastern	22,519	34,514	88,330	74,688
89,527	8,657	43,980	55,571	3,814	N. Mid.	23,309	47,775	221,603	122,021
69,555	4,774	28,955	66,313	3,826	S. Mid.	12,832	21,017	140,652	89,082
55,128	4,770	29,378	49,981	2,557	S. Wales	5,753	25,009	101,262	69,929
94,753	8,294	25,571	47,928	4,628	N. Wales	12,886	40,436	228,553	59,747
146,897	1,602	17,050	42,707	2,674	S. Lancs.	12,976	75,645	429,697	46,475
87,057	6,185	30,144	44,778	3,375	N. East	10,571	42,420	206,960	59,712
59,599	3,628	23,483	35,734	2,158	N. West	8,355	31,935	146,974	37,833
44,485	2,530	15,775	23,593	2,724	Northern	4,595	13,417	96,189	51,282
20,193	4,744	7,185	13,192	330	Ireland N.	130	2,288	36,632	1,240
61,415	5,183	24,475	35,569	1,458	Scot. East	3,296	11,666	141,032	47,985
82,273	7,357	24,139	41,598	689	Scot. West	12,159	24,189	210,364	35,299
1,552,329	70,324	360,234	671,744	37,350	Totals.	173,149	484,449	4,349,216	894,575
1,518,776	71,435	357,715	664,668	36,658	Figures at 31st March, 1927.	168,711	469,674	4,173,675	902,782

MECHANICAL TANDEM EXCHANGE.

J. Hedley, M.I.E.E.

ARTICLES appeared in this Journal in July, 1924, January, 1926, and April, 1927, referring to the above exchange. The first by Mr. F. I. Ray, dealt mainly with a description of the circuit operation, the next by Mr. P. B. Frost furnishes details of the Power Plant, and the latter by Col. T. F. Purves, included a general outline of the traffic facilities available.

As the Tandem Exchange has now been brought into service, some further details concerning the equipment and its general development to render it suitable for actual working conditions will probably be of interest.

The introduction into service of the Mechanical Tandem Exchange enables an entire revision of routing of small blocks of junction traffic outgoing from the various manual exchanges in London to be accomplished.

Present Routing Conditions via Manual Exchanges.

Under complete manual working conditions, junction traffic outgoing from an exchange to any other exchange within the same multi office area, is handled in one of the following four methods :—

(*a*) *Straight order wire working.*

Order wire working, with large groups of outgoing junctions associated, terminating on a distant B position, accommodating circuits incoming from the exchange concerned only, for the completion of direct traffic between the two exchanges.

(*b*) *Split order wire working.*

Order wire working with smaller groups of junctions associated than under (*a*) terminating on a distant B position, accommodating circuits incoming from two or more exchanges, for the completion of direct traffic only.

(*c*) *Ringing junction working.*

Junctions not exceeding five in number terminating on a distant B position, accommodating circuits, incoming from two or more exchanges, with small groups of junctions operated on a call and clear signalling basis, for completion of direct traffic only.

(*d*) *Lending junction working.*

Junctions outgoing to a junction centre exchange B position, accommodating circuits, incoming from two or more exchanges, with small groups of junctions, for completing indirect traffic to other manual exchanges.

The design for the Mechanical Tandem Exchange was based on the assumption that the following traffic should circulate *via* that Exchange :—

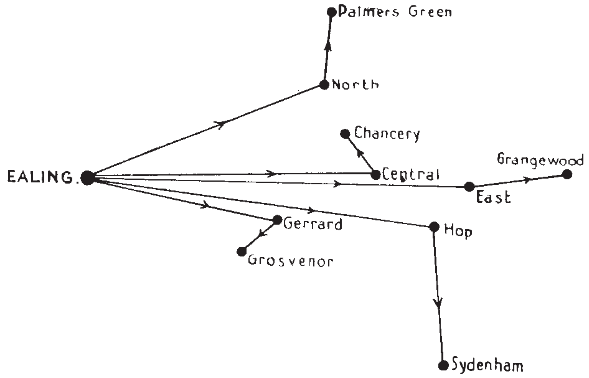
New Routing Conditions via Mechanical Tandem Exchange.

(A) All traffic at present routed under (*d*), *i.e.*, the manual junction centres at

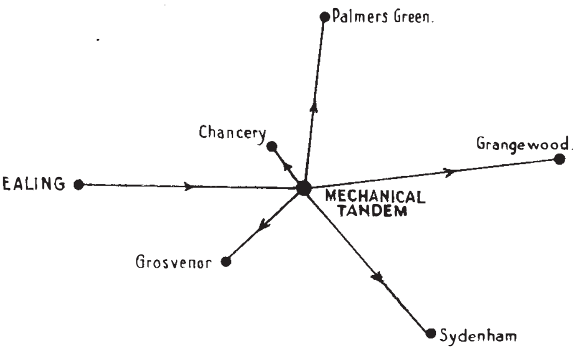
Central, Hop, Gerrard, North, East, and Croydon will be superseded by the Mechanical Tandem Exchange.

Fig. **1** is a typical example for one exchange showing the present and new routing conditions from Ealing, for indirect routing to a few exchanges.

(B) All traffic under (*c*) except short cross country routes between exchanges in comparatively close proximity to each other, where direct routing can be justified on an annual charge basis and all traffic under (*b*) at present carried by junctions not exceeding four in number.



Present method of indirect routing from Ealing, via Junction Centres.



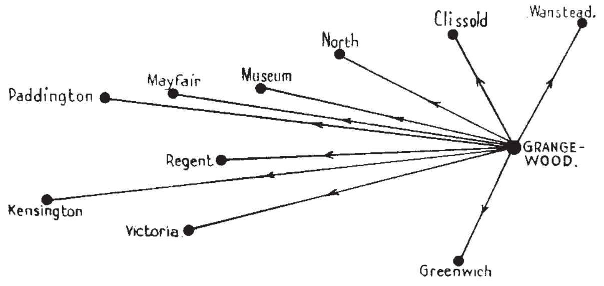
New method of indirect routing from Ealing via Mechanical Tandem.

Fig. **1**.

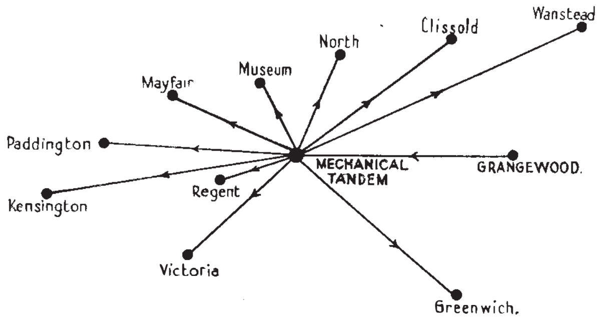
Fig. **2** shows the present direct routing conditions for (*b*) and (*c*) to a few exchanges from Grangewood and the new indirect routing *via* Tandem:—

By collecting the various small groups of traffic under (A) and (B) for each of the exchanges in London, and circulating it *via* the Tandem Exchange, the number of junctions required is sufficient to justify straight order working with large groups of junctions, thus providing more efficient operating and service conditions for all outgoing junction traffic from each exchange in the area.

As all the circuits outgoing from the Tandem Exchange terminate in call indicator equipment at the distant manual exchanges, and Selector Switches at automatic exchanges, the call value to the originating A operator for all junction calls will be equivalent to straight order wire working, thus enabling an overall saving in A operators positions throughout the various exchanges in London.



Present method of direct routing from Grangewood.



New method of indirect routing from Grangewood via Mechanical Tandem.

Fig. **2**.

Similarly the number of B positions in the existing manual exchanges will be reduced by the adoption of a Call indicator working, and the abandonment of lending work in the junction Centre Exchanges.

As regards the facilities for routing traffic, the design of the Mechanical Tandem Exchange is equivalent to that of a Director Automatic Exchange, which requires that the numerical equivalent of the first three letters of all exchange names shall be different, consequently traffic *outgoing* from the Tandem Exchange is confined to exchanges, manual or automatic, within a radius of 10 miles, *i.e.*, to all exchanges within the London multi office automatic area.

For traffic *incoming* to the Tandem Exchange unrestricted facilities are available for the reception of calls from manual and automatic exchanges.

(*a*) Within the 10 mile radius.
(*b*) Outside the 10 mile radius, but within the present London Telephone area.
(*c*) Toll exchanges.
(*d*) Zone Centre Trunk exchanges.

At the outset (*a*) will comprise 79 manual exchanges with 1,849 incoming junctions, and (*b*) 29 exchanges with 368 incoming junctions.

With the development of the Automatic system in London, the 79 manual exchanges under (*a*) will gradually disappear. As each manual exchange is superseded by an automatic exchange, the traffic outgoing from the latter will be routed automatically, by the Director, *via* the most suitable automatic exchange in the network, direct to the call indicator position for manual subscribers, or to selector switches for automatic subscribers. The result will therefore be that eventually the keysending positions, approximately 80, at present accommodating the 79 manual exchanges referred to under (*a*) will be available for the reception of additional traffic from exchanges under (*b*) and for traffic incoming from (*c*) Toll areas and (*d*) Zone centres, from those exchanges having sufficient traffic terminating in the multi office area to warrant order wire working.

Some of the exchanges under (*c*) are:—

Exchange.
Aldershot.
Ascot.
Aylesbury.
Brighton.
Cambridge.
Chatham.
Chelmsford.
Colchester.
Eastbourne.
Folkestone.
Guildford.
Hastings.
Hertford.
Ipswich.
Luton.

Exchange.
Maidenhead.
Maidstone.
Margate.
Portsmouth.
Reading.
Slough.
Southampton.
Southend.
St. Albans.
Tunbridge Wells.
Walton-on-Thames.
Watford.
Weybridge.
Windsor.
Woking.

The exchanges under (*d*) are:—

Exchange.
Birmingham.
Bristol.
Cardiff.
Hull.
Leeds.

Exchange.
Liverpool.
Manchester.
Newcastle.
Sheffield.

Quite apart from the magnitude of the equipment provided in the Tandem Exchange, to meet the foregoing requirements, the complexity of the automatic plant and circuit arrangements, not only in the Tandem Exchange, but connected to each call indicator position in the various manual exchanges, was recognised from the outset as representing the most difficult and colossal operation yet undertaken by the British Post Office, and probably by any other administration.

It was in fact realised that the keystone of the London automatic system was the rendering of satisfactory service *via* the Tandem Exchange. Consequently, as a precautionary measure, it was decided to instal an experimental trial installation in order to afford an opportunity for proving from an engineering standpoint that the various new types of automatic and manual call indicator circuit arrangements functioned satisfactorily, and also to enable operating requirements to be improved, before the Tandem Exchange and call indicator positions were opened for public service.

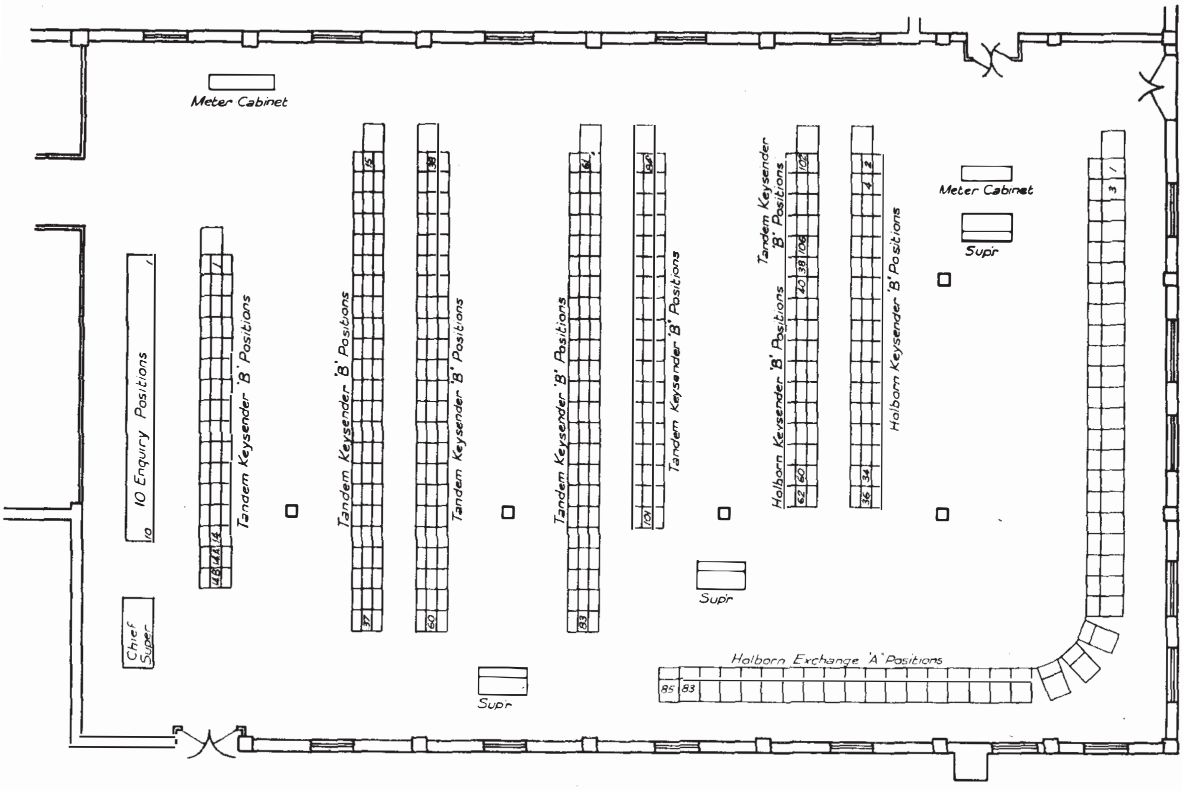
TRIAL EQUIPMENT.

The equipment was located in the City Exchange and comprised the following:—

1. Two Tandem order wire B positions associated with selectors and senders being part of the main equipment of the Tandem Exchange, but fitted temporarily in the City Exchange. Position 1 equipped with 40 incoming junctions and Position 2 with 20 junctions.
2. One Call indicator B position fitted with 36 circuits forming part of the main City Exchange Call indicator group of positions.
3. The A operators in the City Exchange were afforded access *via* 2 order wire keys and 60 junctions in the outgoing junction multiple, direct to the 60 equipments on the two Tandem positions, thus enabling traffic between

two City Subscribers to be circulated *via* the Tandem and Call Indicator equipment at any time.

4. The director equipment in the Engineer-in-Chief's Automatic Training School, was provided with outlets *via* repeaters and Coders direct to the Call Indicator position in the City Exchange, thus enabling calls from Automatic Subscribers to be dealt with.


Meter Cabinet
Meter Cabinet
10 Enquiry Positions
Tandem Keysender 'B' Positions
Tandem Keysender 'B' Positions
Tandem Keysender 'B' Positions
Tandem Keysender 'B' Positions
Tandem Keysender 'B' Positions
Tandem Keysender 'B' Positions
Holborn Keysender 'B' Positions
Holborn Keysender 'B' Positions
Supr
Supr
Supr
Chief Supr
Holborn Exchange 'A' Positions
1
10
14
4A
4B
15
37
38
60
61
83
84
101
102
106
38
40
60
62
2
4
34
36
1
3
83
85

FOURTH FLOOR

FIG. 3.—LAY-OUT OF MANUAL SWITCHROOM, MECHANICAL TANDEM.

The facilities thus afforded by the trial equipment were similar to those which will obtain in actual practice with the additional advantage that the conditions enabled each and every call to be supervised and traced from start to finish.

The results obtained during the trial may be considered as representative of those under regular public service.

Scheme of Trial.—The following progressive scheme was adopted:—

(1) Complete engineering test out of the equipment.

(2) Application of artificial traffic loads by engineering officers.

(3) Application of artificial traffic loads by engineering officers with the assistance of operators at the A, Tandem, and Call Indicator positions.

(4) Application of artificial traffic loads by the Traffic Staff.

(5) Application of regular traffic between two City Exchange Subscribers.

(6) Application of artificial traffic by Engineering Staff from the Training School Director equipment direct to the Call Indicator position.

This programme was adhered to throughout the trial, small variations being introduced from time to time to meet local traffic and engineering requirements.

Minimum loads were applied in the first instance and these were gradually increased, the effect of the increases on plant operation, operating methods, order wire congestion, and incidence of faults being carefully observed.

Method of operating. The introduction of mechanical tandem working does not vary the existing operating practice, so far as CB order wire working at A positions is concerned. At the terminating Exchange, however, the CB order wire position now becomes a Call Indicator position, and in addition the mechanical tandem operator is interposed between the A and B positions.

The experience gained from the trial equipment indicates that with the introduction of mechanical switching at the intermediate point, together with the fact that the control of the connection is vested in the originating A operator, once the connection has been keyed up by the tandem operator, makes it necessary for more definite operating methods to be adopted.

Under the new conditions one or more of the following operating irregularities may affect the successful connection of a call.

A Operator.

1. Passing wrong number to Tandem operator.
2. Mistaking number of junction assigned by Tandem operator.
3. Taking up wrong junction, either as a result of (2) or otherwise.
4. Withdrawal and reinsertion of plug in junction jack, after call keyed up by Tandem operator (equivalent condition to re-ring under manual operation).
5. Overthrow of speaking key to ringing side during restoration of key to normal.

Conditions (1) to (3) are normal irrregularities which may occur under any system of order wire working, (4) and (5) may also occur but do not result in any permanent interruption to the complete manual connection; but with the control of the Connection in the hands of the A operator a " no display " fault, or lost call, is liable to occur if these two operating methods continue under mechanical tandem working.

Tandem Operator.

1. Mistaking number demanded by the A operator.
2. Keying up wrong number, either as a result of (1) or otherwise.
3. Depressing the assignment key of a junction, other than the one verbally allotted to the A operator.
4. Irregular depression of keys:—
   (*a*) Flicking the keys.
   (*b*) Excessive pause between exchange code and numerical digits.
   (*c*) Keying up before sender associated.
   (*d*) Unequal time interval between digits.
5. Insufficient pause between operation of cancel key and re-keying.

Irregularities (1) to (3) may occur under any system of order wire operation, (4) and (5) result in lost calls but can be guarded against during the normal training of the Tandem operators.

Call Indicator Operator.

1. Irregular engaged testing, *i.e.*, touching the bush of the multiple jack with the ring of the plug, instead of with the tip of the plug only.

This faulty testing may clear the display from the position and result in a lost call, as the subsequent insertion of the plug in the multiple jack is liable to fail to find the junction associated with the calling subscriber. The marker pilot lamp glows, without a display, for the next call and the operator extends to the information desk, by the depression of the service key and decoder release key.

2. A similar condition is liable to occur due to irregular operating, during the process of withdrawing a plug from the multiple on receipt of a clearing signal, by the operator allowing the sleeve of the plug to make contact with the tip of a disengaged plug, or earth on any part of the position.

The above two conditions can only be obviated by operating methods.

Although it is necessary to arrange for more careful operating, it is equally essential that the maintenance of the plant should receive special attention.

The development of automatic routine testing methods for application to the most important parts of the equipment, such as senders, relay groups, etc., and call indicator positions generally, will certainly tend to bring faults under notice more quickly, but more frequent testing of junction lines either by manual or automatic routine methods will be essential in order to detect faults on the external lines themselves and in addition the incoming rotary line switches at the Call Indicator exchanges will need to be proved for correct rotation. Faults on these parts of the equipment may cause the sender in the Tandem Exchange to fail to discharge and result in a " no display " fault and lost call.

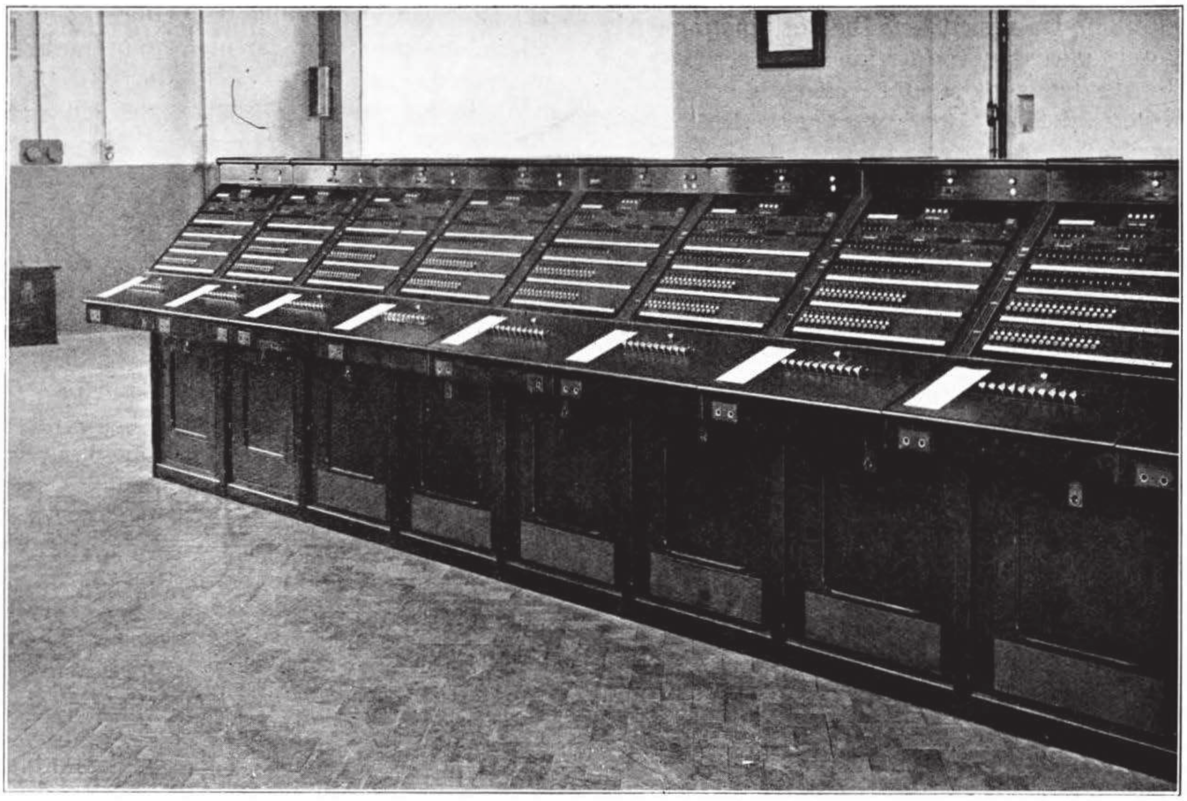


Fig. 4.—A portion of the Suite of Positions.

Experience under actual working conditions, based on the improved arrangements as regards operating and maintenance testing, shows that the foregoing defects are of very rare occurrence, and the observation results compare most favourably with those under ordinary manual working.

Traffic Observations. — Observations were taken by the Traffic Staff during the regular " traffic " trial.

The method adopted was for the observer to listen on the order wire. After hearing the number asked for and the Tandem operator's assignment, the observer transferred the listening set to the junction allotted and recorded the progress of the call.

Appendix A. shows the result of calls between November 16th to December 15th, 1926, and December 30th, 1926, and January 8th, 1927.

Routine Indicator.—To enable the engineering staff to observe the operation of the plant, routine indicator equipment was linked with the Tandem and Call Indicator apparatus as follows :—

Three lamp display panels. The top display indicated the number corresponding to the exchange code sent into the sender, as the result of the Tandem operator keying, the centre display indicated the subscriber's number sent in, and the lower display, the number recorded on the Call Indicator position.

40 Keys and lamps were also provided and linked to the 40 junction circuits on the Tandem position.

By listening on the order wire the observer was thus in a position to check the progress of a call by means of the junction lamps and display signals. In addition, a printing tape machine was associated with the routine indicator—the tape was used primarily to check the correct operation of the digit Keys by the tandem operator—but subsequently it afforded valuable data to be obtained to prove that interruptions in the junction loop were occurring after the circuit had once been taken by the A operator, and also that the Call Indicator operator was making engaged tests incorrectly.

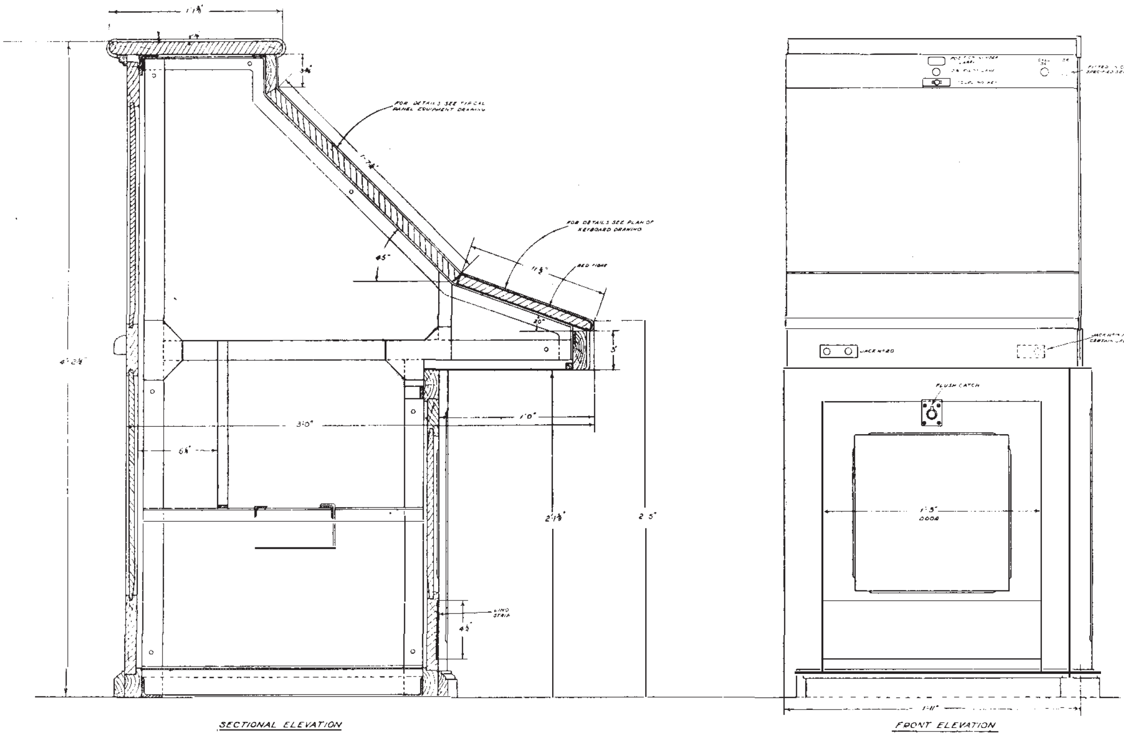


FIG. 5.—CROSS SECTION AND FRONT ELEVATION OF SECTION, CORDLESS B.

Facilities were available for making the following observations:—

1. A operator's demand on order wire.
2. Tandem operator allots junction and assigns.
3. Junction lamp flashes.
4. A operator plugs in and lamp glows steadily.
5. A operator plugs into wrong junction corresponding lamp flickers whilst lamp of assigned junction flashes.
6. Tandem operator keys up. This appears on two top display lamps whilst correct spacing and depression of keys appears on tape machine.
7. Number appears on Call Indicator position and is duplicated on bottom set of display lamps.
8. Call Indicator operator tests and plugs into number required, both displays released and called subscribed rung.
9. Ringing tone heard and called subscriber answers.
10. Called subscriber engaged. Call indicator operator depresses busy Key—Busy tone heard.
11. Called subscriber clears, junction lamp ceases to glow.
12. Call Indicator operator tests incorrectly, display released but no ringing or busy tone, and junction lamp ceases to glow.

APPENDIX A.

RESULTS OBTAINED WHEN PASSING PUBLIC TRAFFIC (CITY EXCHANGE LOCAL TRAFFIC) THROUGH THE EXPERIMENTAL M.T. AND C.C.I. EQUIPMENT.

Item.	Nov. 16 to Dec. 15.		Dec. 30 to Jan. 8.	
	No. of calls.	%	No. of calls	%
1. Calls received at C.C.I. position.				
(*a*) For which a display was received	35,655	99·44	12,844	99·57
(*b*) For which only a " Marker-Pilot " was received ...	203	·56	56	·43
(*c*) Total calls received at C.C.I. position	35,858	—	12,900	—
2. Result of special observations made.				
(*a*) No. of calls observed ...	15,014	41.8	3,531	27.40
(*b*) No. of calls O.K.	12,869	85·74	3,075	87.09
(*c*) No. of calls ineffective due to " no reply "	149	·99	45	1.27
(*d*) No. of calls ineffective due to " No. engaged "	1,302	8.66	234	6.63
(*e*) No. of calls ineffective due to " Wrong number " connected	298	1.98	57	1.61
(*f*) No. of calls ineffective due to " Miscellaneous reasons "...	396	2.63	120	3.40
3. Busy Hour load on C.C.I. position	(Not recorded)		405	

Note.—Period for which order wire was guarded against interruption after depression of assignment key ... 3 seconds. 2 seconds.

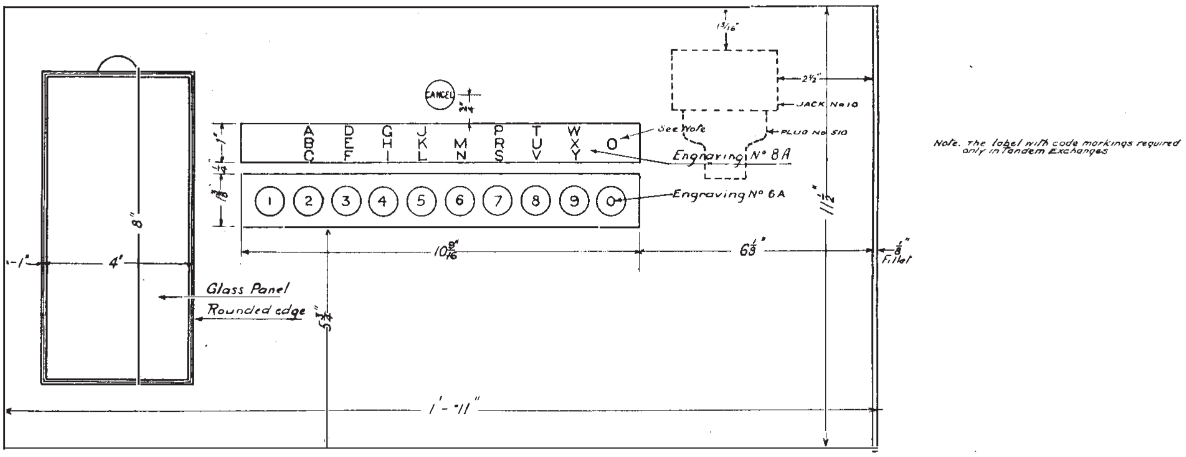


FIG. 6.—KEYSHELF EQUIPMENT, CORDLESS B POSITION.

The experimental trial equipment was completed early in 1926. Tests 1 to 4 under Scheme of Trial followed until the plant was brought into use for public service in September, 1926, and the results obtained have amply justified the preliminary action taken. The arrangements whereby the various items of plant were located in one building were ideal for tracing engineering circuit defects and testing out improved circuit conditions, and also for bringing under notice causes of bad service due to operating and engineering methods, which would otherwise have had to be dealt with during the period of installation and testing out, under the less favourable conditions of the Tandem Exchange equipment widely separated from the distant Manual Call Indicator positions.

In addition to the elimination of defective engineering conditions, from a circuit operation standpoint, three important operating changes were made as the result of the experience with the trial equipment :—

1. Guarding the Tandem operator on the order wire for a definite period varying from 2 to 3 seconds, after the allotment of a junction to the A operator, so as to enable her to be free from demands from other A operators whilst keying up the number.

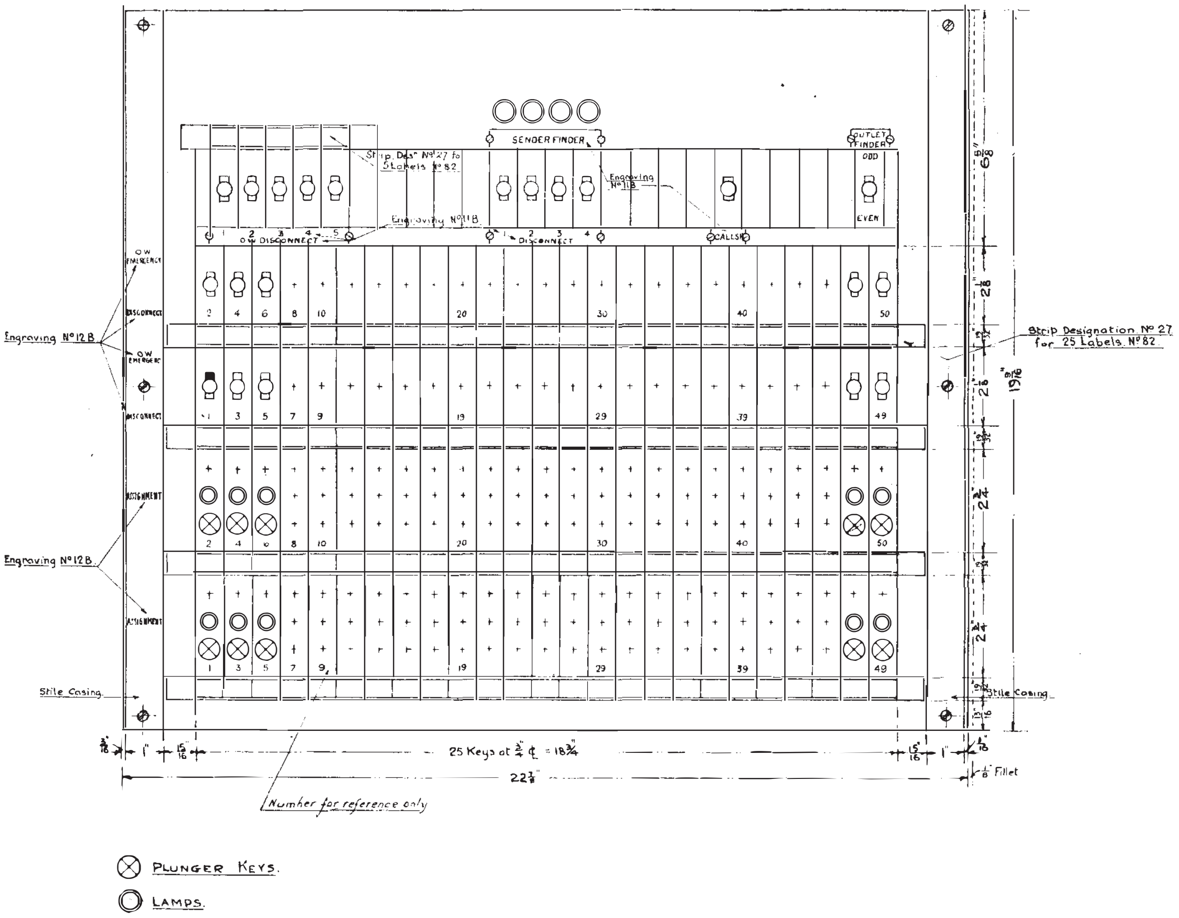


Fig. 7.—Panel Equipment, Cordless B Position.

2. Altering the equipment to make it immune from fleeting disconnections by the A operator, such as those caused by the reinsertion of the plug or overthrow of speaking key, until the call is actually keyed up by the Tandem operator and transmitted to the distant exchange by the sender.

3. Furnishing a steady glow on the assignment lamp of the Tandem position immediately a sender is available, thus enabling the Tandem operator to commence keying up practically immediately after the depression of the assignment key, except on the rare occasions when all senders are engaged. The original scheme provided for the supply of a flashing signal when the sender was found and a steady glow when the A operator picked up the assigned junction. This method tended to delay the keying up by the Tandem operator, as when a sender was found in the dark period of the flashing signal the lamp signal might not be received for a maximum of 3/4 seconds.

Tandem Exchange Equipment Details.

108 positions have been provided, each with capacity for 50 and equipped for 30 incoming junctions. Fig. **3** shows the lay-out of the manual switchroom, and Fig. **4** a portion of the suites of positions. Fig. **5** is a dimensioned section of a position. Fig. **6** indicates the key-

shelf equipment, the strip of digit keys can be changed, if required, by withdrawal of the plug, attached to the digit key strip, from the jack fitted inside the apron of the keyshelf. Fig. **7** shows the panel of one position equipped for 50 junctions; the two bottom rows of lamps and keys are associated with each junction, for supervision and assignment, the next two rows of keys for disconnecting the junction, and replacing the order wire if faulty; the top row includes 5 keys for disconnecting the order wire when replaced by a junction, 4 sender finder lamps and disconnect keys, a supervisor's call key, and a change over outlet finder key. Fig. **8** shows the disposition in the automatic switchroom, of the junction relay groups, senders, etc., associated with the keysending positions and also the lay-out of the selector racks. The automatic plant includes 6,806 group selectors and 170 senders. Fig. **9** shows a portion of the automatic switchroom. Fig. **10** shows the trunking scheme in use when the exchange was brought into service on August 18th, indicating that provision is available for routing traffic to 100 exchanges. Arrangements are already in hand to extend to 150 outlets.

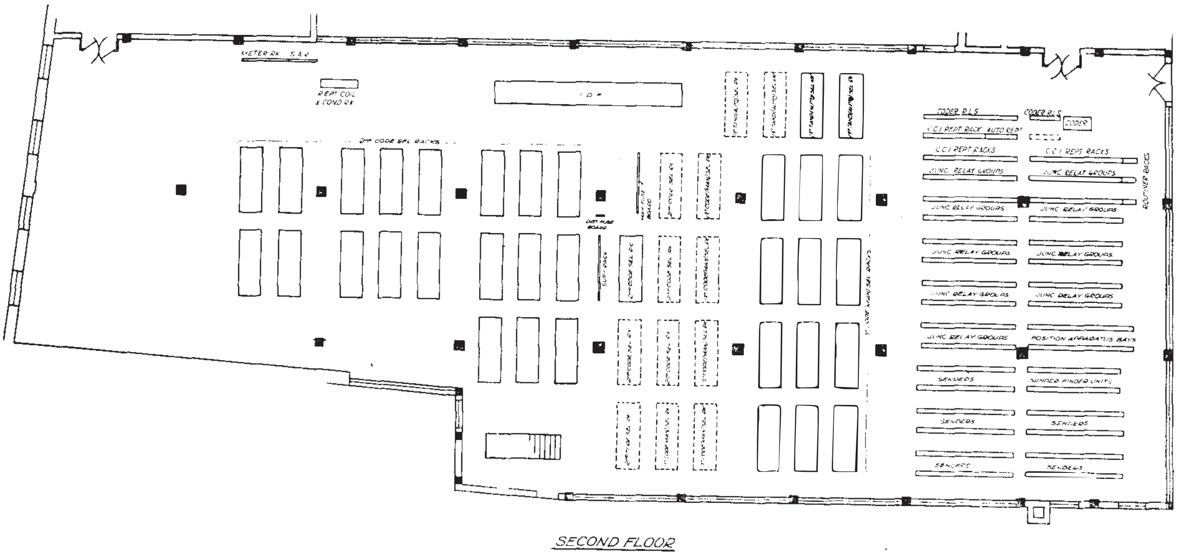


FIG. 8.—LAY-OUT OF AUTOMATIC SWITCHROOM, MECHANICAL TANDEM.

FUNCTIONS OF LAMPS.

1. *Junction lamp.*—One lamp supervision is provided for each junction, as follows:—

(*a*) When assignment key depressed and a free sender is found the lamp glows and continues to glow whilst the A operator's plug remains connected with the assigned junction.

(*b*) When order wire emergency, or junction disconnect key is operated, the lamp glows.

(*c*) When A operator plugs into an unassigned junction, lamp flickers.

2. *Sender Finder lamp.*—One lamp is provided for each of the 4 sender finders on each position to indicate which of the 4 sender finders are in use.

FUNCTION OF KEYS.

1. *Assignment key.*—One per junction depressed prior to operation of digit keys to bring the sender and position finder circuits into operation.

2. *Disconnect and order wire emergency key.*—One per junction, the downward position is used, for disconnecting the junction from service in the case of a fault, or for releasing the sender should the tandem operator wish to recommence keying after a call has been incorrectly keyed up; the upward position joins the operator's telephone to the junction when the latter is used to replace a faulty order wire circuit.

3. *Order wire disconnect key.*—One per order wire,—5 of which are provided per position —for disconnecting the operator's telephone from the order wire, when the latter is faulty.

Cancel key.—One per position depressed by the operator when the digit keys are known to have been wrongly operated, during the process of keying up. The Sender is released and the operator may immediately recommence keying up, without again depressing the assignment key.

Sender release conditions.—The sender releases after a predetermined period (8 to 16 seconds) or by the depression of a 2nd assignment key, whenever the Tandem operator depresses an assignment key and fails to key up any digits, or keys up incompletely, or after a complete set up by the Tandem operator should the A operator fail to take the junction.

Digit keys free for next call.—Immediately the Tandem operator completely keys up a number, the outlet finder will step to the next contact, to connect the key strip to an idle sender finder, thus permitting the operator to set up another call.

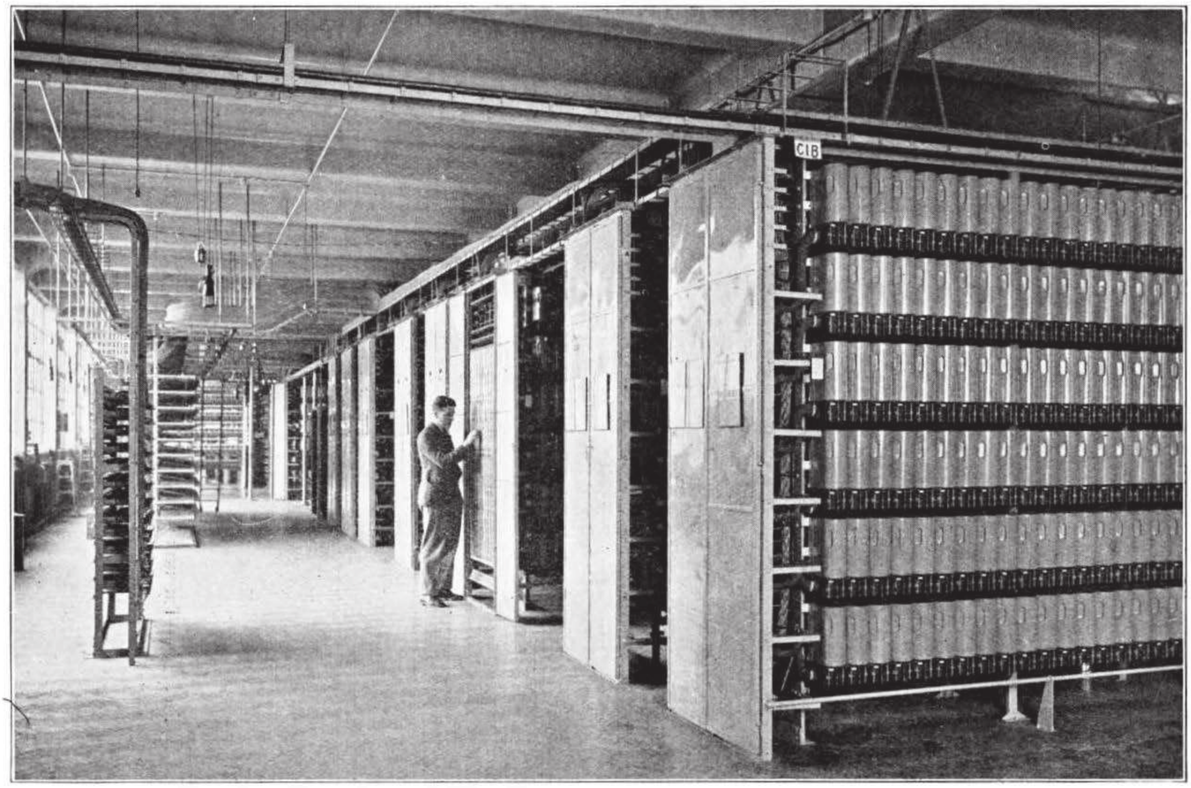


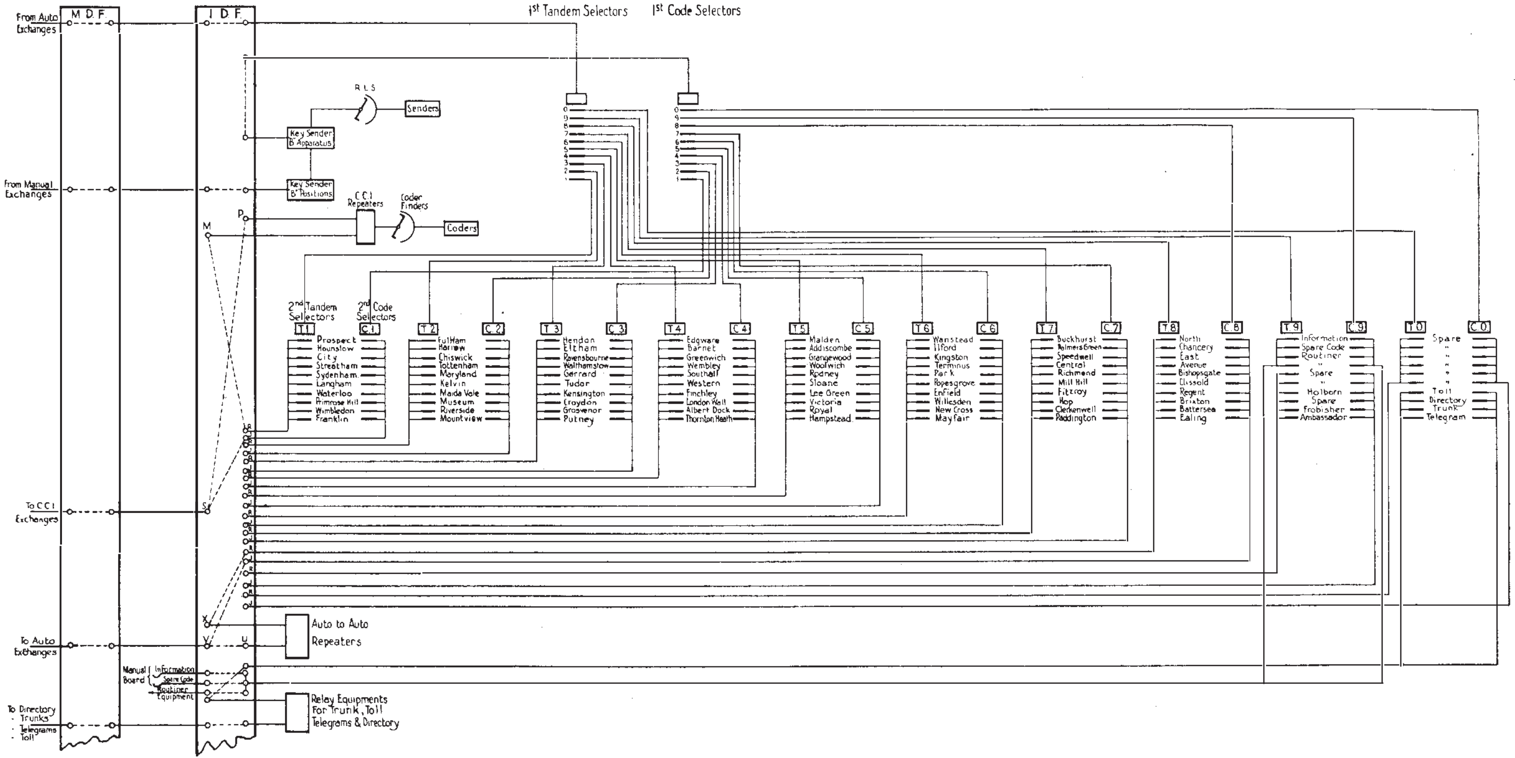
FIG. 9.—A PORTION OF THE AUTOMATIC SWITCHROOM, MECHANICAL TANDEM.

Sender Finder key.—Four per position used for engaging the outlets to 25 senders, if the outlet is faulty. The associated sender finder lamp glows.

Outlet Finder key.—One per position. Two sets of 4 outlet finders are provided per position. The upward position of the key is associated with one set and the downward position with the other. The position of the key is changed each day so that one set of outlet finders is available in case of a fault.

Grouping of Senders.—Capacity exists for 200 senders. Each half of the positions has access to 100 senders—85 of which are provided.

The key set is connected to a sender *via* a position outlet finder which controls 4 outlets per position, *i.e.*, 4 " junction " finders and 4 sender finders. Each sender finder has access to a maximum of 25 senders, consequently each



Typical Jumpering Scheme on I.D.F. shown dotted.		
Route	To Manual Exchanges.	To Auto Exchanges
Incoming from Tandem "B" Positions	J to S	J to V
" " Automatic Exchanges	R to M and P to S	R to X and U to V.

FIG. 10.—TRUNKING DIAGRAM. MECHAGICAL TANDEM EXCHANGE.

position has access to any sender in its own group of 85.

At this stage a brief statement of the operating facilities will probably be helpful.

Manual Subscriber calls an Automatic Subscriber obtained via the Tandem Exchange.

The A operator passes the call over the order wire to the Tandem operator, the latter allots a junction to the A operator, and at the same time depresses the assignment key associated with the junction.

Junction assigned. — Junction and sender finder switches operate simultaneously, to find the assigned junction, and first free sender. The Tandem operator's telephone is disconnected from the order wire, and a tone is placed on the latter for a period of approximately two seconds, for the purpose of protecting the Tandem operator from interruption during the process of keying up the exchange code and number demanded by the A operator.

Junction lamp glows.—When an idle sender is found, the junction supervisory lamp glows, as an indication to the Tandem operator to commence the operation of key sending. The junction lamp will glow throughout the call until the A operator withdraws the calling plug. No disconnecting work by the Tandem operator is necessary.

Junction lamp flickers.—Should the A operator insert the calling plug before the Tandem operator depresses the assignment key, or should a junction be plugged into other than that allotted by the Tandem operator, the lamp will flicker. The continuance of a flickering lamp signal is an indication to the Tandem operator to route the call to the Monitor by keying up INF.

Operation of Sender.—As the first three digits always concern the exchange code portion of the number demanded, the sender is arranged to operate the group selector code switches as soon as the 3rd digit has been set up. The sender translates the 3 digits of the exchange code to route *via* the desired levels of the 1st and 2nd code switches. The 2nd code switch rotates automatically to find a junction to the desired exchange.

When the operator has keyed up 7 digits, 3 for the exchange code and 4 for the subscriber's number, the sender automatically sends ordinary dial impulses to the distant automatic exchange selector switches. When the 4 digits of the subscriber's number have been transmitted, the called subscriber is rung from the final selector in the automatic exchange and the sender returns to normal, the junction circuit is also transferred from the sender to the calling subscriber so that conversation may proceed.

Standard supervision and busy flash is afforded to the originating A operator.

Manual Subscriber calls a Manual Subscriber obtained via the Tandem Exchange.

The operation by the Tandem operator does not differ, but the sender instead of transmitting ordinary dial impulses, for the 4 digits of the subscriber, translates them into coded signals to operate decoding relays associated with the call indicator equipment in the manual exchange. The decoding relays translate the signals into the numerals of the required subscriber's number, which are displayed on a lamp display panel on one of the call indicator positions. The operator at the latter point inserts any idle cord into the multiple jack of the displayed number.

Arrangements for rendering Public Service.

The scheme of transfer from the existing manual conditions to mechanical tandem and call indicator working must necessarily be a gradual one. Quite apart from the magnitude of the engineering work involved in arranging for the installation and testing of 78 exchanges with call indicator equipment on 316 positions, it will no doubt be appreciated that the education of the staff in the new operating methods has also necessitated an immense amount of intensive study and training by all concerned.

The Engineer-in-Chief's Training School has helped very considerably by affording facilities to all grades of the engineering and traffic staff to obtain tuition and first hand information under ideal conditions. Mr. Anson's article in the July, 1925, issue of the Journal supplies full details of the School equipment.

Frequent meetings were held in order to arrange for the closest co-operation between the engineering and traffic staffs, and it was finally agreed that the scheme of transfer should be as follows :—

1. Divide the call indicator exchanges into 7 zones, corresponding to the existing manual junction centres.
2. Complete the call indicator equipment in zone order, commencing with Croydon and its two associated exchanges at Thornton Heath and Addiscombe and following with—

East	and	7	associated	exchanges.
North	,,	8	,,	,,
Hop	,,	16	,,	,,
Central	,,	8	,,	,,
Gerrard	,,	18	,,	,,
and the				
City	,,	10	,,	,,

3. Artificial traffic to be operated for staff training purposes.
4. Public service to be operated when 3 zones completed, following with the remaining zones.

Artificial traffic under (3) was commenced on Feb. 11th, 1927, by arranging for the incoming junctions on certain Tamden positions to be permanently engaged by the distant A operator. The Tandem operator then assigned and keyed up numbers from a schedule to one of the Call indicator exchanges, say Croydon. The numbers received at the distant exchange were subsequently checked against those keyed up from the schedule in the Tandem Exchange.

Public service under (4) commenced on Aug. 18th, 1927, to the 18 exchanges in the Croydon, East and North zones.

It will be realised from the foregoing description that for the first few years after the introduction of automatic working in London, the Tandem Exchange will be the only general "clearing house" for all indirect traffic within the London area, commencing with the reception of traffic from all the manual exchanges *within* the 10 mile radius, and routing to *manual* exchanges only.

As automatic exchange working develops other "clearing houses" for the reception of indirect traffic from automatic exchanges will be introduced, until ultimately the Tandem Exchange will be utilised mainly for the reception of traffic from manual operators at exchanges *outside* the 10 mile radius, and routing *to automatic* exchanges only.

This article would be incomplete without making reference to the great improvement in speech transmission which has resulted in consequence of the introduction of the Tandem Exchange. This has been achieved by means of new cables, loaded in many cases, provided between the Tandem Exchange and the various exchanges in the London area. A distinct improvement in the service throughout the London area will therefore be afforded, as the worst transmission for any connection *via* the Tandem Exchange will not exceed 30 miles of standard cable.

SUBSCRIBERS' APPARATUS IN AUTOMATIC AREAS.

H. G. S. Peck, B.Sc. (Hons.), M.I.E.E.

PART I.—TELEPHONE AND IMPULSE CIRCUITS.

THE object of this present article is to describe the circuits that have been standardised for use at subscribers' offices on lines connected to automatic switching equipment and to refer to the various conditions that have governed their development.

Various aspects of this subject have already been dealt with from time to time chiefly by Col. Purves in his paper "The Post Office and Automatic Telephones," read before the Institution of Electrical Engineers on 5th March, 1925, a summary of which can be found in Volume XVIII. of this Journal.

The impulses by which the automatic switches are controlled have their origin in the dial on the subscriber's telephone and it will be useful to state at the outset, even at the risk of a charge of plagiarism*, what is a standard impulse and to describe the cause and the results of distortion of such impulses.

A train of standard impulses consists of a series of " breaks " of .067 second separated by " makes " of .033 second. The movement of the mechanism in the switching equipment is determined by the number of breaks which corresponds to the digit dialled.

Variation in the total duration or period of an impulse or what amounts to the same thing in the number of impulses per second, can only arise from variation in the speed of the dial. The " standard " rate of impulsing is 10 per second, but in practice dials are maintained in service provided the rate of impulsing is not less than 9 nor more than 11 per second.

Departure from the ratio of 2 : 1 for the break and make portions of a train of impulses is known as impulse distortion. It may arise from faulty construction or adjustment of the dial, or from the effect of relay lag or from the circuit conditions as described below.

If the length of the breaks in a train of impulses sent into an automatic switch be increased at the expense of the makes, a point will be reached at which their duration has been so reduced, and consequently the magnetisation of the B relay so attenuated that it will fall away during the train of impulses and prematurely complete a circuit for the operation of the release magnet of the switch.

If the breaks be shortened either by increasing the makes or by increasing the rate of impulsing, the time of energisation of the vertical and rotary magnets will be reduced and a point will be reached when this period has become so short that the switch mechanism will fail to count the impulses, which condition will arise in the step-by-step system through lack of sufficient time for the mechanism to move past the " dog " which retains it in its stepped position after each impulse.

The speed of a dial may be reduced very considerably before the switching mechanism will fail, which failure will occur owing to the fall back of one or other of two slow release relays, resulting in either the operation of the release magnet or the premature change over from vertical to rotary movement.

The truthfulness with which a train of impulses is reproduced by the contacts of the line relay in the switching equipment will vary with the resistance, leakage, capacity and inductance in circuit with the impulsing contacts of the dial and the relay.

Resistance by reducing the magnitude of the current tends to delay the pull up of the line relay. It also makes it more ready to fall away and the combined effect of these two tendencies is to shorten the time of the make of the relay contact and to lengthen its break. Leakage by maintaining a small current whilst the impulsing contacts of the dial are open has the reverse effects and so lengthens the time of make and shortens the break.

An inductance in series would delay both the pull up of the relay and its fall off. The effect on the times of make and break of the relay due to capacity between the lines depends upon its magnitude and distribution in relation to the other constants of the circuit. In general the make is increased, although a lumped capacity gradually increased from zero actually decreases the time of make until a critical value of about $\frac{1}{4}$ or $\frac{1}{3}$ microfarad is reached, after which the make increases at an average rate of $2\frac{1}{2}\%$ per microfarad.

The connections of the telephone also have an effect upon the character of the impulses. The transient effects that occur at the make and break of the dial are of great interest and importance and are conveniently studied by the aid of Figs. **1**, **2** and **3**. It was the proper understanding of these effects that finally led to the standardisation of the impulse circuit shown in Fig. **3**.

The diagrams have been drawn to show the connections with the receiver off the hook and the dial in the normal position. The open arrow heads represent the off normal or auxiliary contacts of the dial which are operated as long as the dial is away from its position of rest. The solid arrow-heads represent the impulse contacts which are interrupted as the dial returns to normal, the number of interruptions or im-

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* *See C. W. Brown, I.P.O.E.E.J., Jan.* 23. *Vol. XV., p.* 303.
do. do. July, 24. *Vol. XVII., p.* 128.
L. H. Harris, I.P.O.E.E.J., Jan. 25. *Vol. XVII., p.* 293.

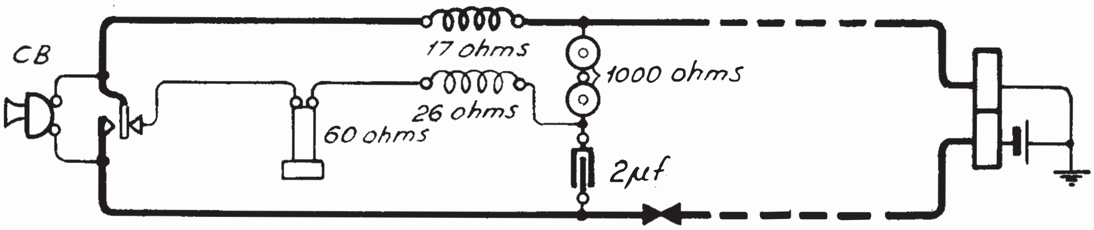

FIG 1. TYPICAL EARLY CIRCUIT.

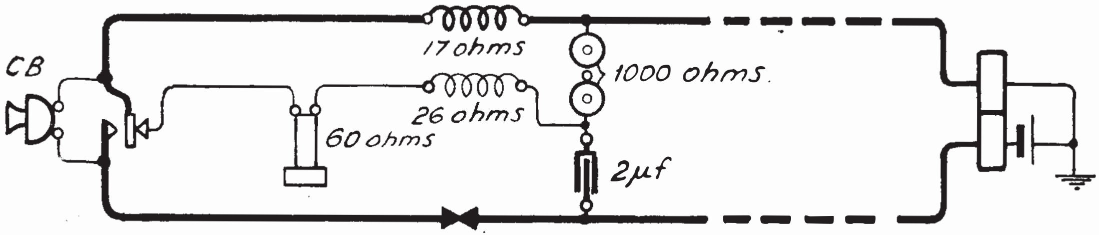

FIG 2. STANDARD TELEPHONE OF 1922.

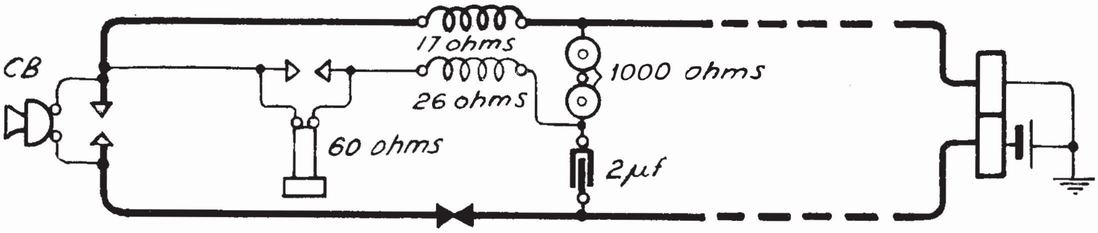

FIG 3. PRESENT STANDARD AUTOMATIC TELEPHONE.

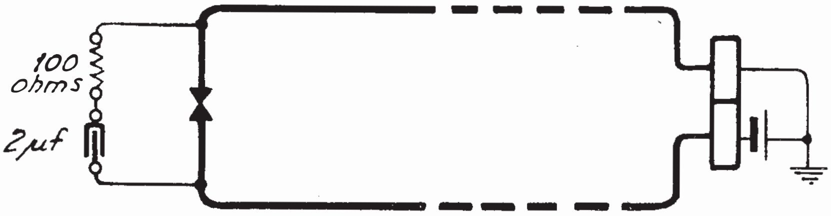

FIG 4. PRIVATE BRANCH EXCHANGE.

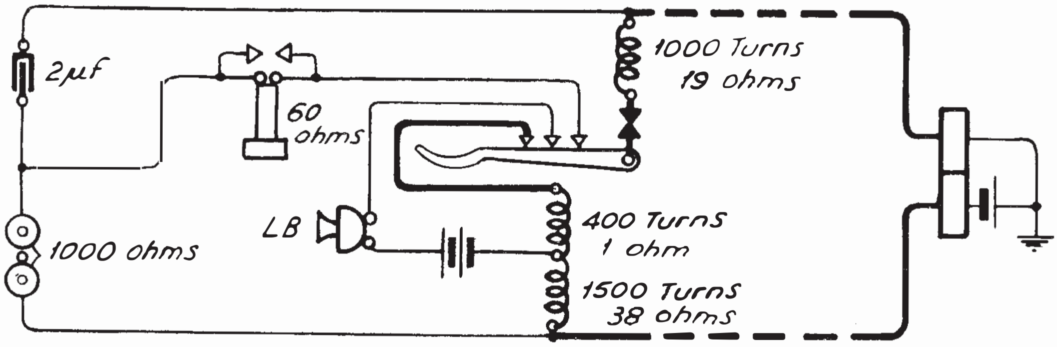

FIG 5. LOCAL BATTERY TELEPHONE.

▷◁ or ▷[◁ indicates off normal contacts of dial.
⧓ indicates impulsing contacts of dial.

pulses depending upon the angle through which the dial has been turned by hand before being released to return under the control of its spring and governor.

The relay, line and telephone together make up a circuit containing resistance inductance and capacity and the usual conditions referring to the rupture of a current in such a circuit apply when the impulse contacts of the dial are opened. The energy stored in the magnetic circuit of the line relay is then released and is eventually dissipated in the resistance of the circuit.

Immediately on the opening of the impulse contacts the magnetisation of the line relay commences to die away and whilst doing so sets up an electro-motive-force in its winding. The magnitude of this E.M.F. depends upon the rate of fading of the magnetisation and this is related to the rate at which the current falls. The direction of the induced E.M.F. is such as to tend to maintain the current and if, as in Fig. **1**, the circuit be disconnected at a point where very little or no capacity is left across the relay the current is forced to die away at a very rapid rate and a correspondingly high E.M.F. will be induced in the relay winding. The energy is then dissipated in the form of a spark or in leakage current through the insulation.

Tests made in the Research Section showed that with this circuit the induced E.M.F. at the break of the dial contacts was 1,050 volts when the connection between the telephone and a line relay of the A.T.M. Co.'s horizontal type was made by 0.1 mile of 10 lb. cable. In practice, however, the capacity of the subscriber's line and multiple connections are generally sufficient to prevent potential differences greater than 900 volts being reached, and when one mile of cable is in circuit the peak P.D. is about 400 volts. Such high P.D.'s as these are liable to cause breakdowns of insulation and to give rise to sparking at any weak point in the wiring.

In Fig. **2** the bell and condenser in series are left in circuit across the relay and line when the impulse contacts are broken, but owing to the impedance of the bell there is no great reduction in the foregoing P.D.'s, a maximum peak value of 700 volts still being reached.

Numerous variants of Fig. **1** were experimented with in connection with the earlier automatic systems. In one the transmitter and receiver were connected in a simple series arrangement which was short-circuited by a single pair of off-normal springs on the dial, the bell being disconnected by the switch-hook; in another there were no off-normal springs at all on the dial, whilst in a third there was one pair of off-normal springs which short-circuited the receiver.

The first of these had a poor transmission efficiency, with the second the dialling impulses were heard in the receiver, whilst in both the second and the third the dialling circuit was completed *via* the transmitter. No deleterious effect on the transmitter could be traced to its inclusion in the impulse circuit, but owing to the possibility of variation in transmitter resistance arising from accidental cause or from future change of design, it was considered advisable that it should be excluded from the impulse circuit.

Four-conductor cords were required with table telephones wired to the circuit, shown in Fig. **1**, and it was with the object of enabling a three-conductor cord to be used that the circuit shown in Fig. **2** (used at that time by the A.T. & T. Co. in the United States) was standardised in November, 1922. Unfortunately, however, this arrangement was found to suffer from two very serious defects in that "bell tinkling" was introduced whilst, as already stated, the peak value of the dialling voltage was not materially reduced.

"Bell tinkling" arises from the variations in the P.D. between the top side of the bell and the Exchange side of the impulsing contacts (Fig. **2**) that occur as the impulse contacts are opened and closed. In the closed condition this P.D. will be less than two volts, on the opening of the contact it may rise to the peak value of 700 volts referred to above falling rapidly off to the P.D. of the battery which is nominally 50 volts, to be again reduced to two volts when the contacts are closed once more.

There is thus a sudden and heavy charge transferred to the plates of the condenser on the break of the dial and a sudden but less heavy discharge on the make. The resulting transient currents flow through the bell coils and their effects are similar to those of the ringing current. The current impulse at the break is greater than at the make and it was thought that, by fitting a "biassing" spring to the bell and making the connections in such a way that the impulse at the break tended to attract the armature to the pole to which it was already held by the spring, the effect of the transient current might be masked, but it is possible with such a circuit that the initial surge may be sufficient to transfer to the plates of the condenser a greater charge than they would carry at their final P.D., and if this occurs there will be a following discharge or series of oscillations.

It was possible in some conditions and with some bells to eliminate tinkling by biassing, but the effect of fluctuations in the P.D. of the ringing bus-bars, the difference between the voltage of the main battery when newly charged and when discharged, the variations in the resistance and composition of lines and the use of extension telephones and extension bells, all combined to render impossible the commercial production and efficient maintenance of bells on which the biassing spring could be so adjusted that whilst a bell would respond to legitimate ringing currents in their weakest condition it would be unaffected by dialling impulses at their strongest.

The circuit shown in Fig. **3**, which has now been adopted for the standard telephone, was first suggested by Mr. R. L. Bell, of the Engineer-in-Chief's Office, in October, 1919. Trouble was then being experienced with breakdowns of insulation and the circuit was suggested as a method of avoiding the creation of high dialling P.D's. Tests were made to determine its efficiency in this respect and it was found that the maximum value of the dialling P.D. did not exceed 180 volts under any practical condition.

The impulses as repeated at the contacts of the line relay were also found to be less distorted when using this circuit than with the earlier circuits, and since all switching equipment supplied up to that time had been developed for use with telephones connected to the earlier circuits the various manufacturers concerned (viz., Messrs. Siemens Bros. & Co., the Western Electric Co. and The A.T.M. Co.) were supplied in February, 1920, with a copy of the proposed new diagram and asked to say whether a change in telephone circuit from Fig. **1** to Fig. **3** would adversely affect the operation of their various equipments.

The circuit shown in Fig. **3** did not, as originally suggested, provide for short-circuiting the transmitter, but for reasons already stated this feature was subsequently added. A Research Report of January, 1920, in referring to the inclusion of the transmitter in the impulse circuit stated " In any case, by fitting an extra contact on the dial, connections could be arranged so that the transmitter is short-circuited as well as the receiver while the dial is rotating." It is, of course, also possible to arrange for the short-circuiting of the transmitter by an additional contact on the switch-hook as is done in A.T.M. Co's patent No. 177130 (application date 29 Aug., 21).

It was the need with this circuit for an additional contact on either the switch-hook or the dial that delayed its introduction until after the difficulties with tinkling and biassing of bells had made themselves apparent in practice. It would in all probability have been adopted much earlier had the dials in use or available been considered capable of operating two independent pairs of off-normal contacts. The dial which eventually permitted of this refinement was developed by Messrs. Siemens Bros. & Co. in collaboration with the Post Office and was described by Col. Purves in his paper referred to above.

When the dial is " off-normal " the impulse contacts in Fig **3** are bridged by a 2 microfarad condenser in series with the 26 ohm winding of the induction coil and when these contacts are opened a circuit of comparatively low impedance is left across the line relay. Its energy is thus dissipated without any considerable rise of potential and sparking at the dial contacts is practically eliminated. The bell circuit, so far as the resulting current surges are concerned, is shunted by the two coils of the induction coil in series and the tendency to tinkle is so reduced that biasing is rendered unnecessary.

The conversion of the energy of the line relay into a current surge with this circuit as compared with a potential surge in the earlier circuits is extremely interesting. The existence of the current surge is demonstrated by the shape of the oscillograms on page 134 of Vol. 17, where the reversal of the line current on the break of the impulse contacts is clearly exhibited.

Following on the decision to adopt as standard the telephone of Fig. **3**, tests were made to obtain suitable arrangements for dialling circuits on manual boards at private branch exchanges, and it was found that the essential condition for the production of similar impulses was the connection of a 2 microfarad condenser across the impulse contacts, but that unless some resistance were connected in series with the condenser there was a liability for the impulse contacts to become blackened and pitted. For this reason a 100 ohm non-inductive resistance has been connected in series with the condenser and the circuit of Fig. **4** which was adopted in February, 1925, has been included in all private branch exchange diagrams since that date.

A local battery telephone for use on long lines in automatic areas has also been developed. Its connections are shown schematically in Fig. **5** and it will be seen that with the dial in the off-normal position the impulse contacts in series with the receiver winding of the induction coil are shunted by a 2 microfarad condenser. The whole of the induction coil windings are included in the impulsing circuit—the effect of this, however, in the character of the impulses is negligible.

A novel and interesting feature of this new local battery telephone is the use of a three winding induction coil connected on the auto-transformer principle. The primary object aimed at was the inclusion of the receiver in a local circuit in order to avoid (or reduce to a negligible value) any demagnetisation of the receiver by a reversed line current and so render it unnecessary to maintain the identity of the A and B wires of the line, but it was also found on test that the three winding coil had a greater transmission efficiency than the standard two winding local battery induction coil. For these two reasons a similar telephone without a dial has been standardised for use on long lines in C.B. manual areas.

The advantages gained by the use of the dialling circuit of the new telephone are clearly demonstrated by the fact that a switch adjusted to operate through 1200 ohms on the old circuit will function satisfactorily through 1500 ohms on the new. If the time of "make" of a line relay on a zero line with 50,000 leak be compared with that on a 1200 ohm line without leak, the variation with the new telephone is only 35% of that with the earlier type.

These gains are of such value in ensuring the stability of operation that it has now been decided that all impulse contacts shall be shunted by two microfarad condensers.

A "POINT SOURCE" OF SOUND.

W. WEST, B.A., A.M.I.E.E.

THE use of distortionless apparatus for converting sound energy into electrical energy and vice versa is practically a necessity for general acoustic measurements. Actually no truly distortionless apparatus exists, though the ideal has almost been attained. With the development of the art of precise acoustic measurement, however, the demands from such apparatus become increasingly more exacting. The problem of the design of sound generators is considerably more difficult than that of sound detectors, since the mechanical forces and displacements must necessarily be vastly greater, amplification being confined to the electrical circuits; interest in this problem extends beyond those who are immediately concerned with sound measurements.

The instrument to be described was recently devised in the Post Office Engineering Research Section, and as far as the author is aware the design is novel. In this design, in addition to the usual requirements of a flat frequency characteristic and absence of amplitude and non-linearity distortion, a further desirable feature was aimed at, namely, that the sound should be emitted from a small space, so that at even a few centimetres distance therefrom the generator may be considered in effect as a point source of sound.

The instrument may be considered as a development of the "Band Loud Speaker,"* which operates by the motion of a thin metal foil strip placed in a steady magnetic field, and carrying the audio frequency electric currents. A very much longer strip is used, but this is folded into a compact unit which is held in place between the poles of a strong magnet.

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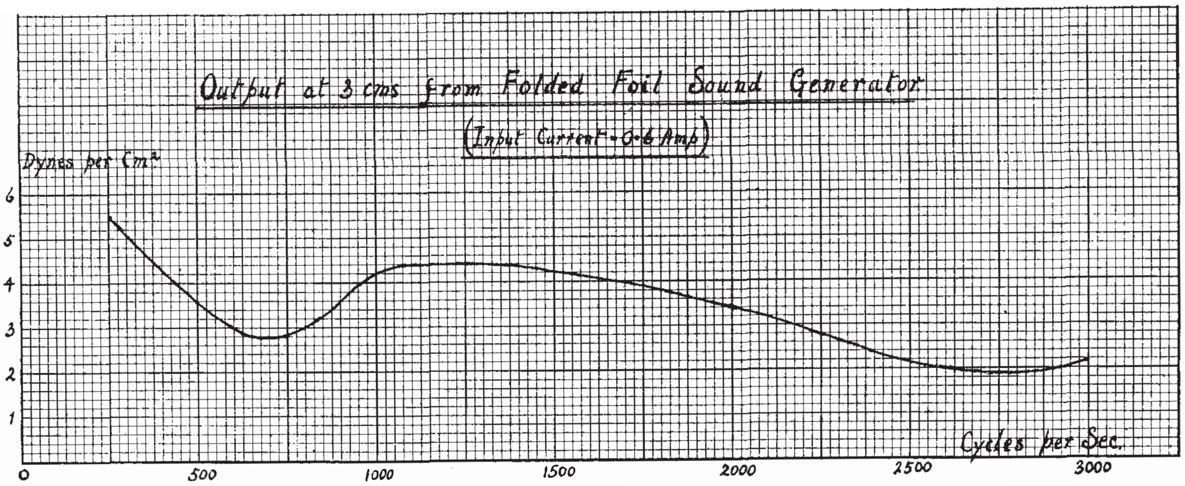
* *W. Schottky: Elektrische Nachrichtentechnik, 1925, Vol. 2, p. 157.*

It will be convenient to explain the construction with reference to a particular instrument, which, though merely an experimental model, has been useful for the purpose of investigating the frequency characteristics of commercial transmitters. In this instrument the magnet has an air-gap of about 2 cms. cube, with a flux density of about 2,500 lines per sq. cm. The strip is of soft aluminium foil, about 0.02 m.m. thick, 2 cms. wide and 80 cms. long, folded at 2 cm. intervals (*i.e.*, pleated), and mounted with the alternate folds fairly evenly spaced, about 1 m.m. apart, in the air-gap of the magnet. The width of the strip lies in the direction of the magnetic flux, and the forces set up, due to an alternating current in the strip, therefore tend alternately to compress and rarefy the air contained in the folds, which communicates directly with the outer air. The front and back faces of the folded strip are separated by a baffle, or by encasing the instrument so that only the front face is exposed.



In common with the Band Loud Speaker, there is a choice of two evils in terminating the edges of the strip. Either the edges may lie in close proximity to thin insulating plates placed between the magnet poles and the folded strip—in which case the whole strip is free to move, but there is of necessity a loss due to leakage of air past the edges; or the edges may be cemented to the insulating plates—thus eliminating leakage, but imposing constraint on a portion of the strip. The latter method is preferred with a very soft and flexible strip, such as the one under consideration, and it results in a reasonably robust and stable structure.

Although no complete record of the performance of the instrument has been taken, the acoustic output has been measured over the frequency range of 250 to 3000 cycles per second. This is shown in the figure in terms of acoustic pressures at a distance of 3 cms. from the instrument, with an electrical input of about 0.6 amp.; since the resistance of the strip was 0.1 ohm, the power input was 0.036 watt. There is also evidence that the general level of the curve is well maintained at considerably higher and lower frequencies. It is significant that, owing to the small mass of the vibrating part, and the direct manner of application of force thereto, there is a complete absence of sharp peaks or valleys in the curve, which is therefore capable of fairly accurate levelling by simple means, such as by bluntly tuned circuits in the amplifier.

The efficiency of this instrument is somewhat low, and it is of interest to consider possible means of increasing the acoustic output. The use of a stronger magnet will, of course, achieve this object, but the dimensions of the strip and air-gap have also to be considered. The thickness of the strip affects both the flexibility and the electrical conductivity of the material, and since, in practice, the thinnest foil which can be obtained in adequate lengths is used, this dimension will be taken as fixed. The input power (I^2R) and the magneto-motive force will also be taken as constant, that is to say it will be assumed that there is no appreciable drop in M.M.F. in the iron circuit of the magnet for the variations in the air-gap under consideration.

Let l = total length of strip
d = width of strip.

Suppose that a portion of this width = k remains fixed (this portion being independent of the width but dependent mainly on the flexibility of the strip), while the remainder vibrates with an amplitude of displacement = a; then $l(d-k)$ is the vibrating surface. Actually the strip does not vibrate exactly in this fashion, but an appropriate value for k will give equivalence to the actual motion. The electrical resistance $R \propto \frac{l}{d}$, and since the input power is fixed, the current $I \propto \sqrt{\frac{d}{l}}$

If it be assumed that the resistance to motion is made up of inertia, frictional and radiation components, each of which is proportional to the surface area in motion, then at any given frequency the mechanical impedance Z is proportional to this area;

$$i.e.,\ Z \propto l(d-k)$$

For a constant M.M.F. the flux density $B \propto \frac{1}{d}$

The force F on the moving part $\propto B.\,l.\,I.\frac{(d-k)}{d}$ since $I\frac{(d-k)}{d}$ is the current in the moving part. Hence the amplitude of motion $a \propto \frac{F}{Z} \propto \frac{1}{d\sqrt{ld}}$ and the volume of air displaced = $a.l.(d-k) \propto \sqrt{\frac{l}{d}}\left(1-\frac{k}{d}\right)$ This is a maximum for variations of d, when $d = 3k$.

Thus the efficiency may be expected to increase with the length of the strip, and, for a given length, to attain a maxmium for a particular width which depends mainly on the thickness and physical properties of the material. This maximum is, however, not very critical. The length of strip may be increased by increasing the lateral dimensions of the air-gap, or by closer folding, which, however, should not reach the limit when attenuation of sound between the folds becomes appreciable.

The further development of this design for other purposes is under consideration.

COLLAPSE OF A BUILDING IN CORNHILL.

H. C. Stone, M.I.E.E.

On the morning of Sunday, August 7th, the Sunday papers published the startling announcement that part of a great block of offices, five stories high, had collapsed in Cornhill, one of the most used thoroughfares in the City of London. The collapse occurred just before midnight on Saturday, and the writer—having been advised in the early hours of Sunday morning by the City Police—was by the time the reports were published actively engaged in endeavouring to ascertain the extent of the damage to the Post Office main route along Cornhill.

Since the war extensive reconstruction works have been carried out in the City of London and numerous offices have been rebuilt, the older properties being replaced by palatial structures of steel, reinforced concrete and stone. In Cornhill, premises had been acquired by Lloyds Bank for the purpose of extending their Head Offices and for the past few months demolition of the old properties and extensive excavation works were in hand. The site, which had been excavated to a depth of approximately 50 ft., had been suitably timbered and the roadway side shuttered and supported, the work being in the hands of a firm of high repute in the City of London. The site adjoins the property of the Commercial Union Assurance Company, and it is probably well known to many of my readers that one of the properties demolished in order to provide for the Bank extension was the renowned "Birch's" Chop House. This house was one of the few remaining links with old

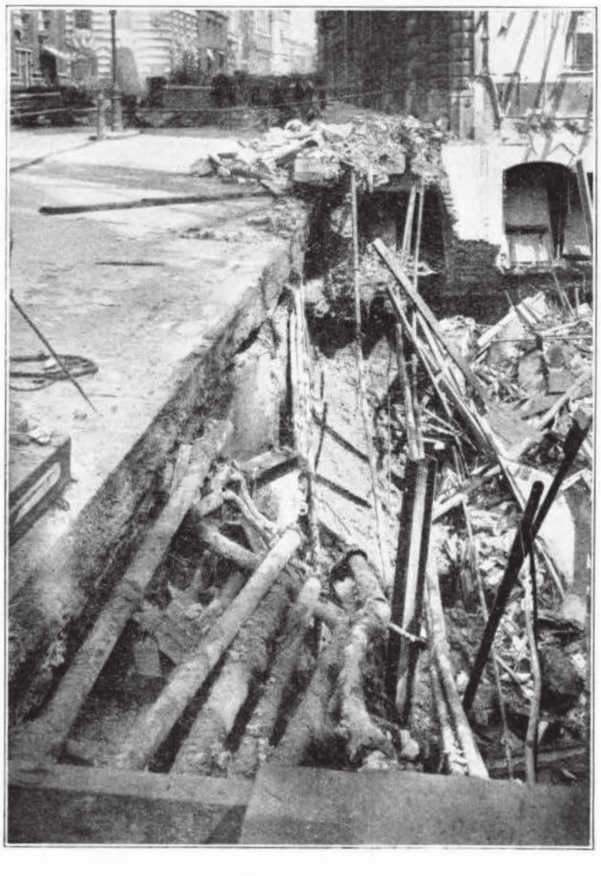


Fig. 1.—Site immediately after Collapse of Building.

London and there was universal regret that such an interesting building had to be removed. The shop front has, however, been preserved and is now in the London Museum.

On the Saturday afternoon settlements were observed in the West wing of the Commercial Union Offices and precautionary steps were at once taken. The settlement, however, developed during the evening and in spite of all efforts the West wing unfortunately collapsed about midnight. The falling building swept away the whole of the footway and the roadway shuttering, with the result that a miniature landslide occurred on the road side, the subsoil falling into the pit, leaving only 12″ of concrete as the support of the roadway at this spot. Figs. **1** and **2**.

Beneath the roadway concrete, at a depth of 5′ to 6′, the Post Office had two main lines of ducts lying adjacent to each other. Fig. **2**. The first line was laid in 1900-1, consisting of a nest of 13 octagonal ducts in concrete. The second line of 15 octagonal ducts was laid some 15 years ago, making 28 in all. The Cornhill route provides one of the main Trunk and Junction arteries between the City, East London and the Eastern Counties and it contains three trunk cables—London-Brentwood-Marks Tey, London-Southend and London-Romford, one main Telegraph Cable from the Central Telegraph Office, ten junction cables and 6 subscribers' main cables, in all close upon 7000 lines. In addition to the above, there were 6 Pneumatic Tubes to Branch Offices in the City, three of which were broken down, and the cables serving subscribers in adjoining buildings.

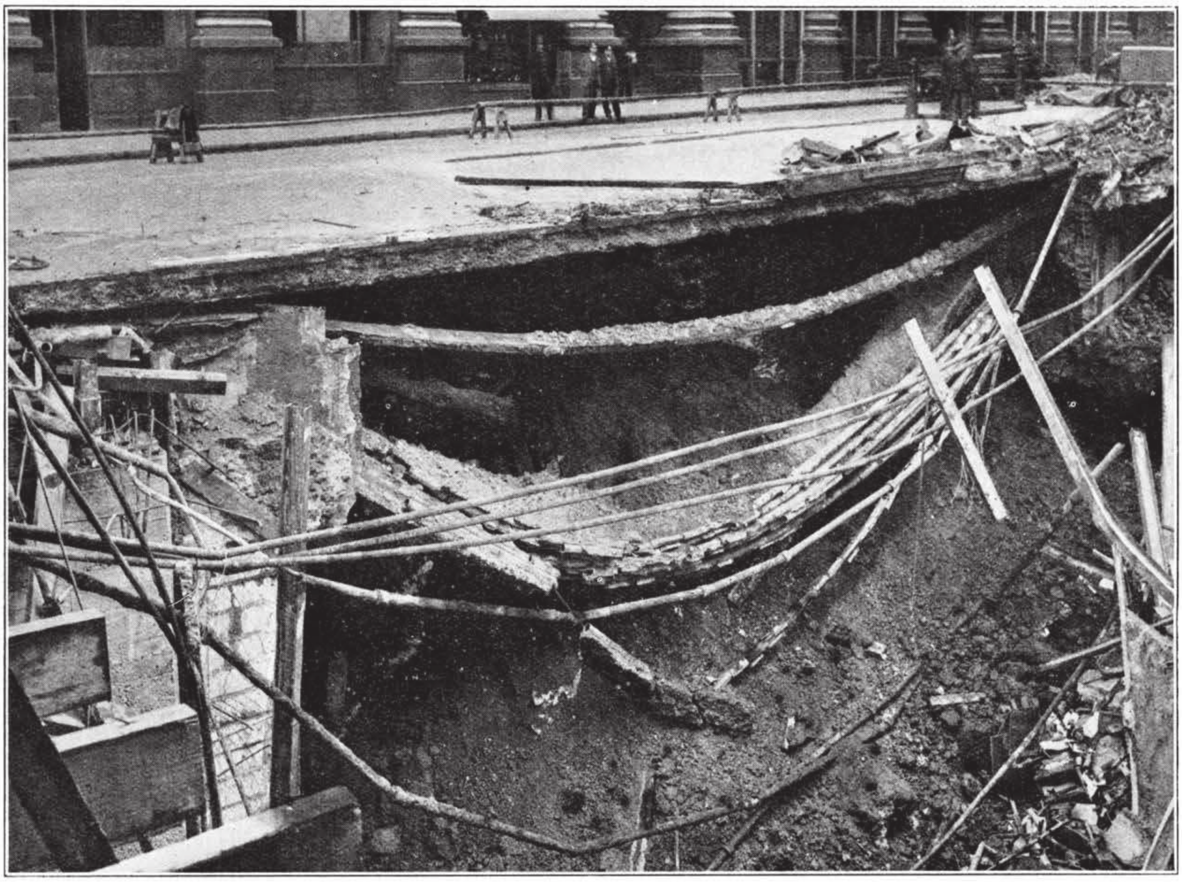
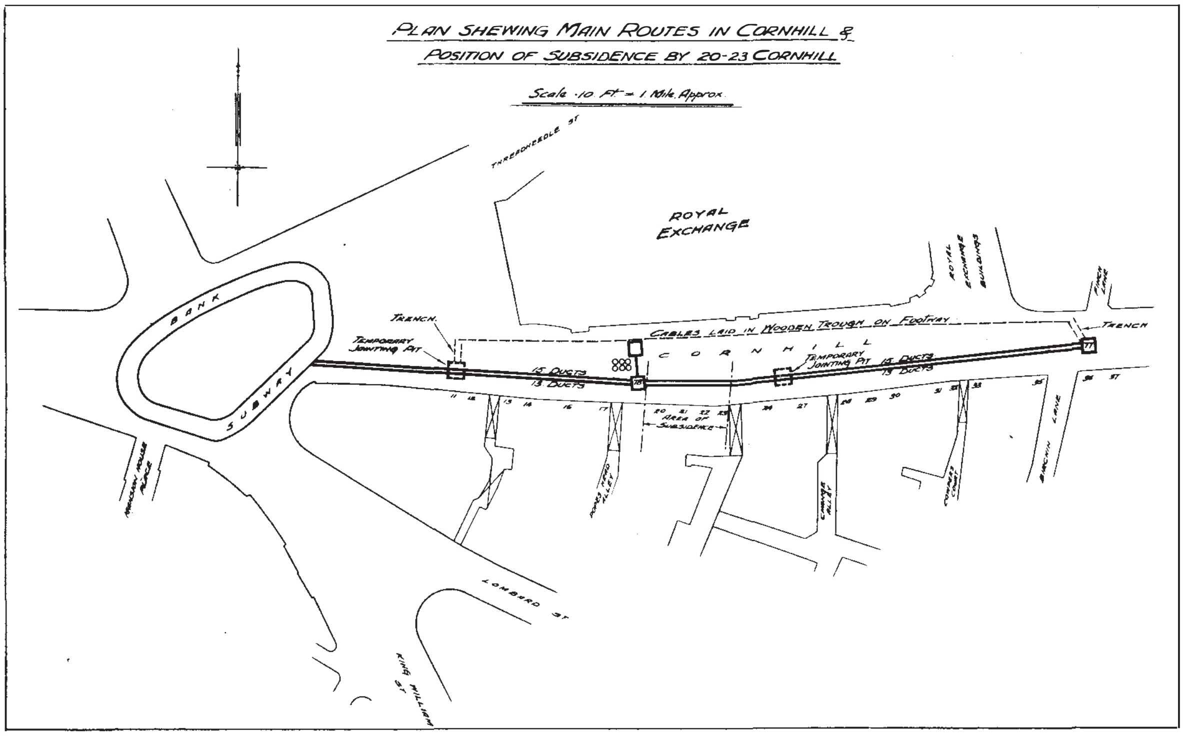


FIG. 2.—POST OFFICE MAIN DUCT ROUTE BENEATH ROADWAY AFTER SUBSIDENCE.

It will be seen from Fig. **2** that both duct lines have gradually sunk with the falling away of the subsoil, the greatest depth of the curve from the roadway level being about 15 feet. It was indeed a fortunate circumstance that the roadway concrete withstood the shock of falling masonry, as otherwise the telephone plant must inevitably have been destroyed, with disastrous results. As it was the cables took up the strain, supporting the surrounding ducts and concrete over a distance of 60 feet. The cables remained in working order after the subsidence and were maintained under these exceptional circumstances until the diversions were effected. This is clearly seen in Fig. **2**. At the time of writing it has not been possible to examine the cables as there is danger of a further subsidence of the subsoil should there be any movement of the cables in the route.



An examination of the manholes on either side of the subsidence showed that the cables had been considerably strained. In the manhole on the east side at Birchin Lane, the cables originally rested on bearers built up from the floor level, the ducts entering the manhole approximately two ft. above the highest cable tier. The cables in this manhole, which was 140 yards away, were lifted into a horizontal position with the bearers hanging and in several instances the joints had been drawn up the duct so that the centre point of the jointing sleeve was at the duct face.

As a result of this survey it was decided to construct a temporary route on the north footway of Cornhill, using 800, 600 and 300-pair lead covered cables. Pits were opened in the roadway over the duct lines at two points on either side of the subsidence, approximately 80 to 100 feet from the same. (See plan). These pits were excavated down to the duct lines, the concrete surrounding the ducts broken away and the cables exposed. Trenches from these pits were cut through the roadway concrete, across Cornhill to the north footway to meet the temporary route. The wooden trough for the protection of the lead covered cables was constructed with 9″ × 3″ timbers, braced at 18″ intervals by 7″ × 1½″ boards as stiffeners. This formed a strong troughing and it was well that such provision had been made, as in the subsequent operations of other contractors engaged upon building restoration work, the cables

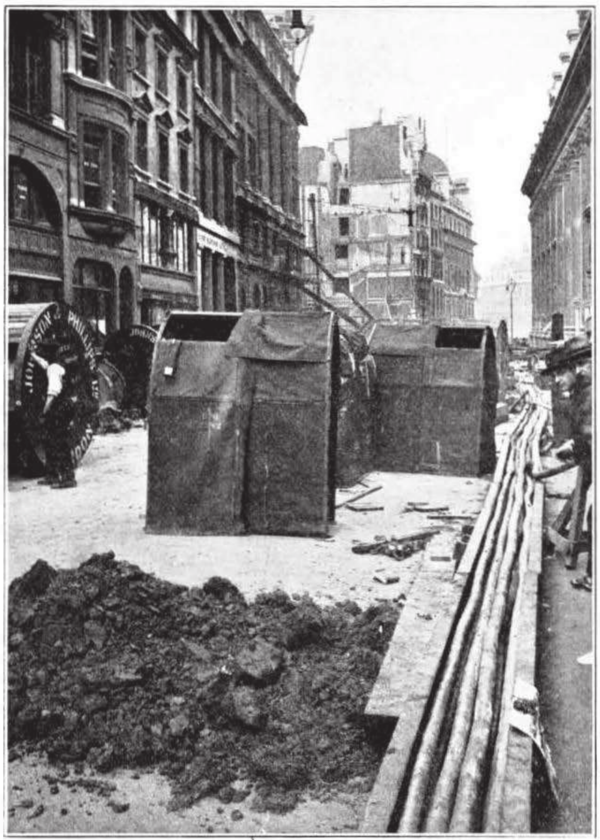


FIG. 3.—OPERATIONS IN CORNHILL SHOWING CABLES IN TROUGHING.

would undoubtedly have been badly damaged on the temporary route by the heavy baulks of timber and girders which were brought on to the site for shoring purposes. The troughing, with the diversion cables in position, will be seen in Figs. **3** and **4**. The troughing contains 12 main cables, into which have been diverted the whole of the lines from the 20 main cables in the original route. For further protection the cable troughing has been closely boarded, as will be seen in the foreground of Fig. **6**.

It should perhaps be mentioned that it was originally intended to divert the cables at a point 80 ft. east of the area of subsidence, but owing to subsequent trouble, which necessitated the shoring-up of part of the Insurance building, it was deemed inadvisable to continue at this spot and the jointing position was shifted further east to the nearest manhole by Birchin Lane. (See plan).

From Fig. **2** it will be realised that the stress on the cable route was a serious factor and likely to cause trouble as the process of changing over the cables progressed and the making spare of the old route necessarily released the cables. To guard against any sudden collapse of the route during changing-over operations, the pit which had been opened at the point nearest the subsidence was strongly timbered and two 5″ × 4″ steel girders sunk in a vertical position and lashed to the " walings " in the excavation. Each cable in the route was then secured by means of stranded steel flexible scaffold ties and fastened to the steel girders. This precaution was amply justified, as upon cutting spare the last conductors in the first cable changed over the old cable slipped quite 6″, that is, until the stress was taken up by the scaffold tie. The same thing happened with other cables so that the route was secured throughout the whole of

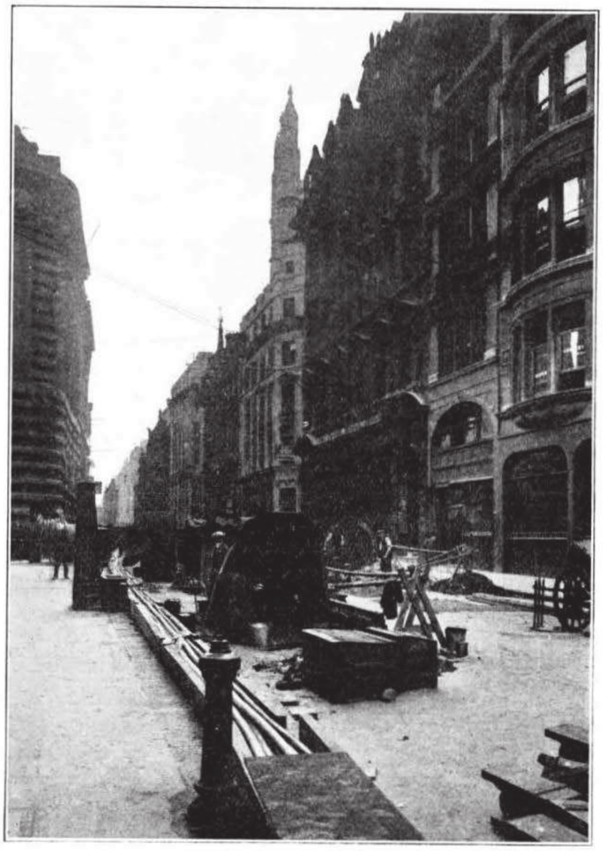


FIG. 4.—TROUGHING LOOKING EAST TOWARDS BIRCHIN LANE.

the operations. There have necessarily been many anxious moments during the diversion period, but by careful attention to points of detail and "safety first" devices the route was ecured from total collapse and a successful transfer effected with but very few faults on working circuits.

There is, however, a humorous side which should perhaps be recorded. During the first week following the subsidence, newspaper reporters were very active in securing copy and the men employed upon the work were questioned by individuals thirsting for information.

A somewhat alarming report appeared in several daily papers that the jointers on the work were seriously troubled with mosquitoes and rats, and were in danger of electrocution by exposed high tension mains or asphyxiation by gas.

The truth is that one jointer reporting for the night shift had been working in his garden before coming on duty and just mentioned that he had apparently been bitten by a mosquito. Also one poor, misguided rat, somewhat scared, escaped along Cornhill. The high tension main was enclosed in a 3″ pipe and, although passing through one corner of the jointing pit, was protected with concrete, whilst the gas arose from the sourness of the soil often met with during excavations adjoining gas mains where leakages have been remedied. Following the reports, however, the writer received many letters of sympathy from well meaning persons, advice for dealing with mosquito scourges, household remedies, etc., together with visits from commercial travellers eager to bring to notice cures for all insect troubles and vermin destructors.

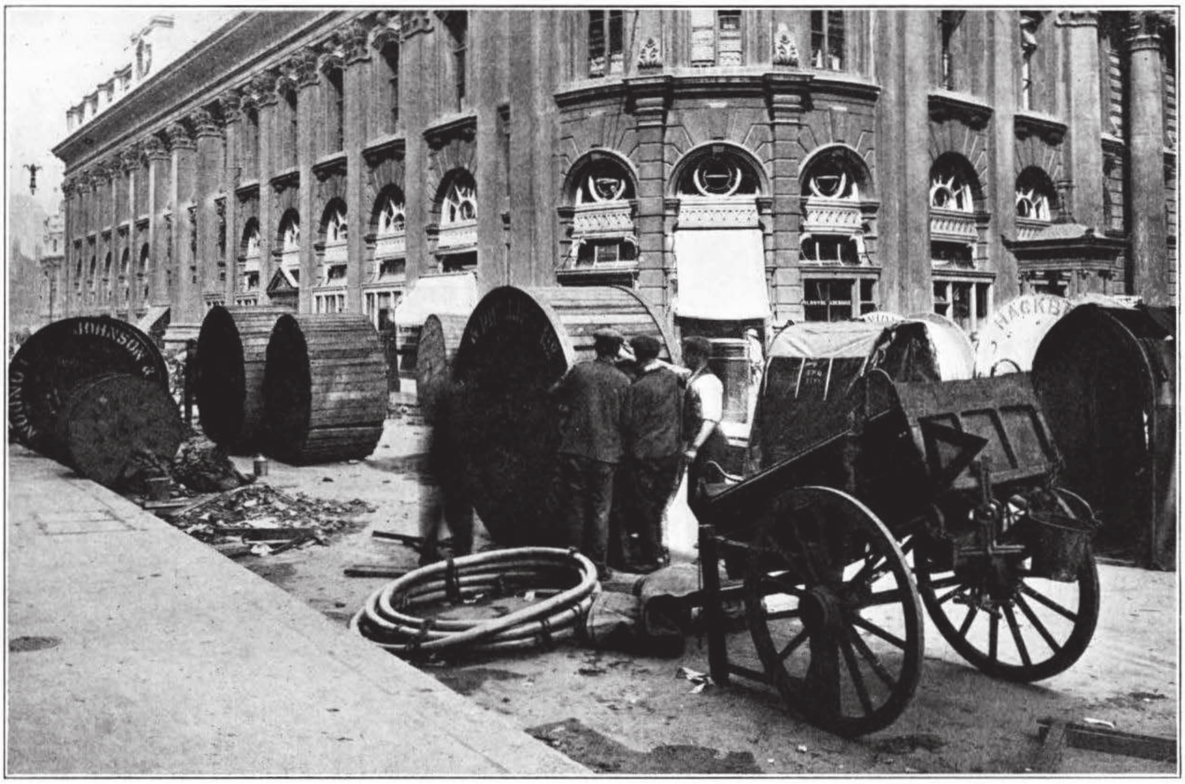


Fig. 5.—The Post Office takes possession of Cornhill.

Two interesting photographs have been taken showing the Post Office activities in Cornhill shortly after the trouble occurred. Figs. 4 and 5 showing the drums of cables and cable trough—" the Post Office takes possession of Cornhill "—and a recent picture (Fig. 6) showing Cornhill spanned by a derrick with the area of subsidence in the distance, literally " Cornhill in splints."

The trenches across the roadway have now been plated over with half inch boiler plate and covered with 12″ of strong concrete, so that lorries containing timber and building material can pass over to the site. At the point where the cables leave the trench for the troughing, baulks of timber, measuring 12″ × 12″, act as fenders screening the cables from traffic dangers. In addition, a guard rail has been provided, as the footway on the north side of Cornhill has been opened for pedestrian traffic.

In conclusion, it should be mentioned that the City Engineer considerably assisted matters by immediately granting facilities for opening the ground so as to get access to plant. My thanks are also due to my Assistant Engineers, Chief Inspectors and all who so readily and unsparingly gave up what would normally be their recreation time in order to further the work of restoration and last, but not least, to the jointers and mates who worked so loyally to restore and secure communications over this important route.

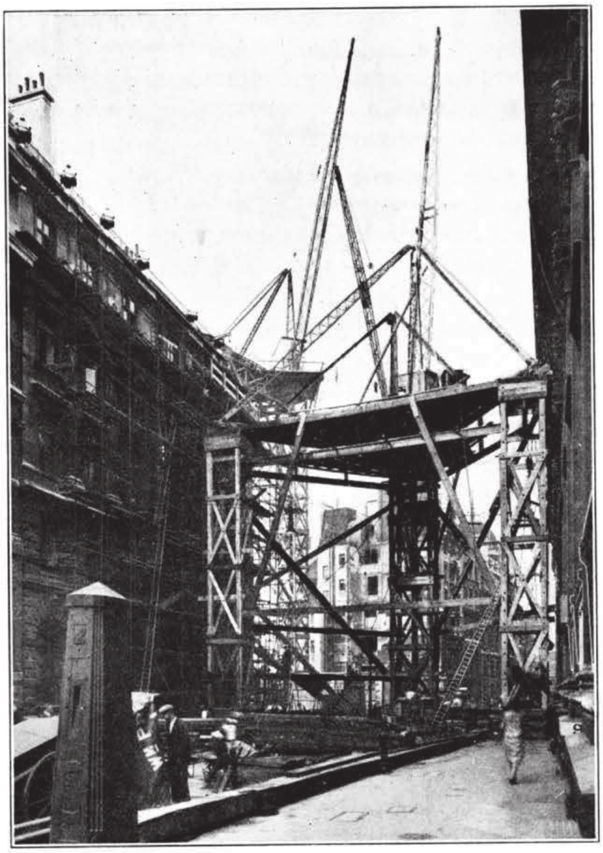


Fig. 6.—Cornhill in Splints. Cable troughing in foreground.

AIR SPACE, PAPER CORE TELEPHONE CABLES OF THE TWIN, MULTIPLE-TWIN AND QUAD TYPES.

A. Morris, A.R.C.Sc., D.I.C., Wh.Ex., M.I.E.E.

Synopsis.—Gives the history of Twin, Multiple Twin and Quad type cables. Compares the direct and mutual capacity ratios and discusses the utilisation in the various core types of their direct capacities for circuit purposes. Gives representative figures for capacity deviations and capacity unbalances of factory lengths of modern high-grade cables. States the features governing the linear dimensions of telephone cables. Describes the electrical requirements of the various classes of telephone circuit—local, junction and long-distance — and discusses the technical and economic features governing the choice of cable type.

General.—Underground telephone cables in general utilise paper lappings for the purpose of securing an air-space separation between the conductors. Such cables are referred to industrially as " Dry Core " cables in contradistinction to the impregnated cables of power systems. They are more completely described as " Air Space, Paper Covered " cables in particular reference to the compound dielectric which consists principally of dry air.

The modern dry-core cable represents the present stage of development of cable communication circuits in which a relatively small electrostatic capacity and low energy loss in the dielectric as well as great economy of space are combined with considerable immunity from electrical disturbance. Compared with the gutta-percha covered, and other early types of cable, they are in all the respects enumerated, a considerable improvement.

The general construction of dry-core cable, from the point of view of the provision of the dielectric is essentially universal. Such cables are classified into types according to the formation or mode of relative arrangement of the conductors into units or cores, whilst cables of the same type differ from each other only in respect of their make up, *i.e.*, size or gauge of the conductor and the arrangement of the unit cores into layers.

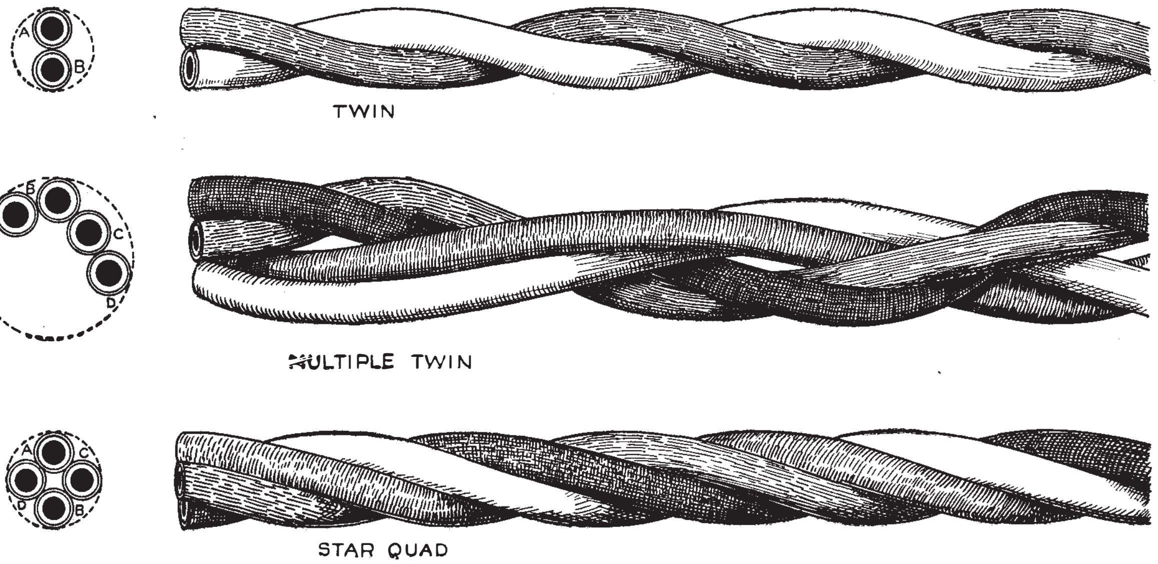


Fig. shows make-up of Twin, Multiple Twin and Star Quad Conductors.

Each type of telephone cable is built up by cabling a number of unit cores into layers, care being taken in modern cables to avoid interference by arranging for adjacent cores to have different lays. The cores are arranged in each layer in the form of helices, all the cores of any particular layer being spiralled in the same direction with the same pitch. The spiralling of adjacent layers is of different and reversed pitch.

Twin Cables.—The basic type of core in all modern telephone cables is the two-wire unit or Twin type core, in which two conductors are taken and twisted or twined together—as in the manufacture of rope—to form a pair. This twinning of conductors for the formation of telephone cable circuits was in general use by the year 1887 and was the outcome of the principles enunciated in 1879 by Prof. Hughes(1) in a paper dealing with interference in aerial lines.

Multiple Twin Cables.—Another type of core may be obtained by the successive twinning of pairs or basic type cores in the manner described by Frank Jacob(2) in 1882. Thus for a two-pair or four-wire Multiple-Twin core, two pairs are twisted together; for a four-pair or eight-wire Multiple Twin core, two such two-pair cores are twisted together and so on. Multiple-Twin cores consisting of more than two pairs are now obsolete, the two-pair Multiple-Twin cable described in 1903 by Dieselhorst and Martin,(3) in which two pairs of different lay are twisted together with a lay, different from either of the pairs, being the standard Multiple-Twin type. In the British Isles such cables are referred to as "M.T." type, on the Continent of Europe as "D.M." (Dieselhorst-Martin) type, and in America as "Duplex" type cables. In all cases physical circuits are formed upon the constituent twin pairs.

Quad Cables. — If four conductors are arranged at the corners of a square and then stranded together in one process about a common axis with a definite lay, as in the early gutta-percha covered telegraph cables of the year 1882, a four-wire unit called a Quad type core is obtained. Such a core is generally regarded as constituting a basic type, although a similar four-wire lay-up may be secured in a two-pair Multiple Twin core in which the pair and multiple pair lays are the same.

Since their inception it has been the practice to arrange for each pair of diagonally disposed conductors of a Quad to form a physical circuit, and in recent years Quads worked in this manner have been referred to as "Star Quads."(4) In some modern Quad cables physical circuits have, however, been formed upon adjacent conductors as in the Jordan-Haugwitz Quad. Quads worked in this manner are referred to as "J.H." Quads.(9) If the Quad type core is regarded as a Multiple-Twin core of equal wire and pair lays, then the J.H. Quad utilises each of the constituent twin pairs as a complete physical circuit, whilst the Star Quad forms each of its physical circuits upon one wire of one pair and one wire of the other pair. In addition, for J.H. Quad working, such constituent twin pairs would have wire crosses inserted in them at certain intervals of their length, for reasons given later.

Great difficulty was experienced in securing symmetry of formation of the early Quad type core when applied to dry-core cables, with the result that considerable interference difficulties were encountered. The interference resulted from the unstability of make-up, and such a large amount of testing work was involved in ascertaining by trial the crosses necessary to neutralise the disturbances, that underground A.S.P.C. Quad cables fell into disuse for telephone purposes shortly after their introduction, although they survived for telegraph purposes for a period of about ten years.

The Quad type as originally designed for gutta-percha telegraph cables and as constructed for short gutta-percha telephone cables in 1891, did not give rise, in a very marked manner, to this interference difficulty. This was due in some measure to the fact that steps were taken to secure stability by forming the quad on a centring of hemp. This mode of construction although followed in the early dry-core Quad cables did not give the desired results, owing to the non-rigid nature of the loosely paper-wrapped wires constituting the cores. In the modern design, a stiffening of the paper tubes has resulted in the accurate and permanent centralisation therein of the conductors, whilst a central string upon which the covered conductors are bedded is used for the purpose of ensuring symmetry of the cores. This extremely important feature of centralisation of the conductors within the paper tubes may be secured either by the use of specially creased or corrugated surfaced paper wrappings or by a spiral whipping of string directly next the conductor, over which the insulating paper is tightly wrapped. 28 miles of 19 Quad, 150 lb. conductor cable(10) was manufactured in the year 1898 and laid between Cricklewood and Eddlesborough, as part of a London to Birmingham non-loaded telephone cable. With modern methods of manufacture, Quad Cables have been revived in Germany under the general title of "Spiral-four" cables, the two methods of working which have, as already indicated, been referred to as "Star" and "J.H."

Side circuit working upon adjacent conductors of a Quad is accompanied by inherent interference difficulties, quite apart from manufacturing irregularities, owing to the fundamental electric and magnetic coupling of the side circuits. This objection has been overcome by Drs. Jordan and Haugwitz, of the A.E.G., in their J.H. Quad, in which wire crosses have been inserted in each side circuit at intervals of about three metres. The crosses extend over a distance of a few centimetres and are inserted during manufacture by means of a special machine. A cross in one side circuit is located at a different place along the core from the cross in the associated side circuit.

Careful consideration has recently been given to the use of Spiral-four cables by the Telephone Administrations of Europe and such cables have been brought into use in certain countries, notably in Holland and Norway. A Quad cable containing 254 pairs of 40 lb. conductors was manufactured in England in 1925 for the British Post Office, and laid between London Toll Exchange and Ealing, a distance of about 10 miles. Several other similar cables have recently been manufactured for the Department. A Quad cable between Utrecht and Rotterdam, a distance of 57.2 kilometres, containing 1.29 and 1.67 mm. conductors, was completed for the Dutch Administration in 1926. The J.H. cable has during the last few years been utilised together with M.T. cable in the German long-distance network.(9) It is also understood that a J.H. Quad cable has been installed between Brussels and Aix la Chapelle, a distance of about 150 kilometres.

Star Quad cores are employed in modern continuously loaded, paper insulated, double lead sheathed, Submarine type cables. The air space in such cables is relatively small, the dielectric consisting almost wholly of paper. The Anglo-Dutch Nos. 2(11) and 3(12) the Anglo-Belgian (1926)(13) and Anglo-French (1926)(14) cables are examples of this type.

Direct and Mutual Electric Capacities.—The direct and mutual electric capacities of the cores of telephone cables have been defined in a previous article.(16) It is shown therein how the magnitudes of the direct capacities differ within certain limits for the various cores of a given multi-core cable and how such capacities may differ within even wider limits for the cores of different cables of the same type and of essentially the same side circuit mutual capacity. It has also been shown in the article just referred to how the direct capacities of a M.T. core combine in constituting the side and phantom circuit mutual capacities. In a more recent article(17) the case of Quad cables has been considered. For the purposes of the present article, general average figures, based upon actual measurements, for the direct and mutual capacity ratios of balanced cores of Twin, Multiple Twin and Star Quad type cores are given in Table No. I. Estimated average figures for these ratios in the case of balanced J.H. Quad cores have also been included in the same Table. Throughout this Table, m is the direct capacity between the wires of a pair circuit, w is the direct capacity between the wires of the different pair circuits of the same core, and a is the direct capacity of each wire to all other cores of the cable, assumed connected to the earthed lead sheath. S, the mutual capacity of a side circuit, is equal to $(m + a/2)$ in the case of a Twin core and to $(m + w + a/2)$ in the case of each of the other three core types, P the phantom circuit mutual capacity for such types being equal to $(4w + a)$.

The modern Star Quad utilises the direct capacity network of a four-wire core in the most efficient manner for the production of a side circuit of minimum relative capacity. Alternatively for a Star Quad core of the same side circuit capacity as for a M.T. core, the space occupied is smaller. It is in this respect that the principal advantage of the Star Quad cable lies, although this advantage is only obtained at the expense of a very much greater phantom circuit capacity.

The J.H. Quad permits of a more equitable utilisation of the direct capacities of a Quad core for side and phantom purposes respectively, and as far as can be seen it is in this respect that it presents advantages over the Star Quad. It has no advantage over the M.T. type in this respect. Neither has it the advantage over M.T. cable that the Star Quad has in respect of space. An economic advantage over M.T. cable in respect of cost of manufacture and a technical advantage in respect of uniformity of mutual electric capacity have been claimed for the J.H. Quad.

TABLE No. I.

GENERAL AVERAGE CAPACITY RATIOS FOR TELEPHONE CABLE CORES OF VARIOUS TYPE.

Core type.	Capacity ratios.				Remarks.
	m/S	w/S	a/S	P/S	
Twin	0.47	—	1.06	—	Test values.
Multiple Twin	0.36	0.18	0.92	1.64	do. do.
J.H. Quad	0.35	0.23	0.84	1.76	Estimated values.
Star Quad	0.10	0.42	0.96	2.64	Test values.

Mutual Electric Capacity Deviations of Factory Lengths.—For two-wire duplex telephone repeater working of cable circuits, an important item of the repeater equipment is the line balancing network. This electrical network simulates the impedance of the line to which it is connected, at those frequencies of the audio frequency range which it is necessary to transmit in order to ensure the desired quality of the received speech. The extent of impedance-frequency correspondence of the line and its normal basic network will depend upon the uniformity of length distribution of the electrical constants of the line. In modern cables the length distribution of conductor resistance and of leakance is normally essentially uniform. Furthermore, the inductance of loading coils and the lengths of loading coil sections of cable deviate only very slightly from their respective average values. Owing, however, to the special features of multi-core telephone cable design and manufacture it is seldom possible to obtain the same value for the mean mutual capacity of the circuits of each layer of any particular cable length, or the same value for the mean mutual capacity of the circuits of a particular layer in each length of a complete cable. Furthermore, the mutual capacity of any circuit of a cable length will generally differ from the mean mutual capacity of all similar circuits in the same layer of the same length. These differences are referred to as capacity deviations and are conveniently classified into " Circuit " and " Length " deviations. Such deviations are inherent to commercial processes and, unless they are maintained within narrow limits, will cause instability of the system. Length deviations of the electrical constants of a circuit give rise to deviations of the actual impedance-frequency characteristics from the mean characteristics for that circuit. The magnitude of these latter deviations, at the higher frequencies within the cut-off point, may be such as to give rise to a value for the singing-point gain of the associated two-wire telephone repeater, which is too low in comparison with that of the normal working gain of the repeater. The direct consequence of this would be a decrease in the working range of the circuit.

Circuit Deviation. — The electric capacity deviation of a circuit is the difference of capacity of that circuit from the average capacity of all similar circuits of the same group in the same cable length, expressed as a percentage of the average capacity of the same group of circuits in the same length.

Length Deviation.—The length deviation of capacity of a group of circuits of a cable length is the difference between the mean electric capacity of the circuits of that group of that length and the average mean capacity of the circuits of that group, of all the lengths of the complete cable, expressed as a percentage of that average mean mutual capacity.

The International Specification for M.T. cables specifies 4% as the maximum value for the mean circuit deviation of the pair or phantom circuits of a factory length, and 12½% as the maximum value for the maximum circuit deviation of any pair or phantom circuit of any factory length of a complete cable. This Specification does not deal directly with length deviations of capacity, but narrow limits are secured in this respect by the practical operation of the clauses limiting the actual magnitude of the mean mutual capacity of side and phantom circuits.

As far as the pairs of M.T. cables manufactured in this country are concerned no difficulty is experienced in meeting the above circuit deviation figures, whilst average length deviations of from 1.5% to 3% are obtained. Phantom circuits of M.T. cables are invariably more uniform for capacity than the pair circuits.

Very large capacity deviations occur in the manufacture of Twin cables, the actual magnitudes occurring in practice being much greater, especially in respect of circuit deviations, than those quoted above for M.T. cable.

Quad type cable appears to lend itself to great uniformity of mutual capacity, experience to date in this country indicating smaller deviations of the pairs of Star Quad than for those of M.T. type. Table No. II. gives representative figures for the M.T. and Star Quad types.

The necessary capacity requirements of repeater sections of cable are secured in modern cables almost entirely by limiting the circuit and length deviations of capacity in the manufacturing stage. In conjunction with the exercise of this manufacturing control, grading or the allocation of factory lengths to definite loading coil sections is the final expedient for minimising length deviations of capacity of loading coil sections. Alternatively the addition of electric condensers may be employed for this purpose. By means of crossing during the jointing of factory lengths into loading coil sections, almost any desired degree of circuit uniformity within such loading coil sections may be obtained, thus ensuring, with the consequent similarity of total capacity of such circuits, a standard basic network, which with minor adjustments may be applicable to the whole of the circuits of a particular group.

TABLE No. II.

MUTUAL ELECTRIC CAPACITY DEVIATIONS IN 176 YARD FACTORY LENGTHS OF UNDERGROUND A.S.P.C. TELEPHONE CABLES.

Cable Type.	Circuits.	Circuit deviations.				Length deviations.	
		Average		Maximum			
		Mean.	Max.	Mean.	Max.	Mean.	Max.
Multiple Twin	Pairs ...	1.88	5.37	3.25	9.45	1.24	4.07
	Phantoms ...	1.12	3.14	2.13	5.90	0.75	2.23
Star Quad ...	Pairs ...	0.87	3.96	1.25	5.22	0.58	2.39
	Phantoms ...	0.65	4.78	0.75	5.63	0.42	2.51

Capacity Unbalances in Factory Lengths of Underground A.S.P.C. Telephone Cables.—Asymmetry in the make-up of telephone cables gives rise to inequalities in the direct electric capacities of the cable cores. Thus, in the case of a single 176 yard length of M.T. cable, these inequalities may average 27 parts in 1000, whilst they may exist to the extent of as much as 80 parts in 1000 in some cores which have been badly crushed during stranding operations. These inequalities are referred to as capacity unbalances; they give rise to unequal electric induction between the wires of different circuits, the direct result of which is cross-talk.

Extensive manufacturing experience of M.T. cables has resulted in exceptionally good capacity balance of this type, not only between the pairs but between phantom and pair and phantom and phantom circuits. The earth balance of the circuits of M.T. cables is also very good.

High grade M.T. cable is much better than Twin cable for balance between pairs and greatly superior for earth balance of pair circuits. It is thought that Twin cables could be improved in this respect, despite the 15% (approximately) greater direct earth capacity of Twin cables as compared with M.T. cables of the same side circuit mutual capacity.

In Star Quad cables the unbalance between pairs not in the same quad is much smaller than between pairs associated in the same quad. Furthermore, the unbalances between non-associated pairs are, on the average, smaller in Star Quad than in M.T. cables. The unbalances between the associated pairs of the cores of Star Quad cable are, however, as far as experience to date in this country is concerned, greater than between adjacent pairs of Twin cables and much greater, particularly in respect of maximum values, than in M.T. cables. This circumstance is explainable since with equal pair circuit mutual capacity in the M.T. and Star Quad types, the direct capacities (w) upon which the pair to pair unbalances depend are about two and one third times those of the M.T. type core. The earth unbalance of the pairs is also greater in Star Quad cables than in those of M.T. type, and this may be accounted for to some extent by the somewhat greater direct earth capacity. Extended experience of Quad cables will undoubtedly result in improved capacity balance, by reason of the inherent symmetry of this type as compared with the M.T. type.

Table No. III. gives representative unbalances for British manufactured 40 lb. conductor cables of 100 pairs or more and also includes the figures of the International Specification for M.T. type cables. The pair-to-pair, pair-to-earth and phantom-to-earth unbalances of this Table follow the universally accepted definitions of such quantities. The phantom-to-pair unbalances are in accord with the pair-to-pair unbalances, one unit of either producing the same amount of cross-talk, *i.e.*, they are the usual 2 $[(p + q) + u]$ quantities of cable unbalance nomenclature.

TABLE NO. III.

CAPACITY UNBALANCES (ALL OTHER CORES EARTHED) IN 176 YARD FACTORY LENGTHS OF UNDERGROUND A.S.P.C. TELEPHONE CABLES.

Cable Type.			Capacity Unbalances in M.M. Fds.					
			Pair to Pair.			Phantom to Pair of same Core.	Pair to Earth.	Phantom to Earth.
			Same Core.	Adjacent Cores.	Alternate Cores.			
Twin		Mean	—	20	—	—	162	—
		Max.	—	78	—	—	1310	—
Multiple Twin	Avge.	Mean	13	13	1	46	39	125
		Max.	38	43	9	208	151	433
	Max.	Mean	16	15	7	70	66	190
		Max.	62	60	25	485	280	700
Star Quad ...	Avge.	Mean	27	5	—	127	77	—
		Max.	116	61	—	538	334	—
	Max.	Mean	37	6	—	—	96	—
		Max.	170	105	—	—	550	—
International Specification for M.T. Cable	Max.	Mean	33	—	—	125	125	—
		Max.	125	—	—	625	600	—

Linear Dimensions of Various Cable Types.—From the complicated nature of the capacity network associated with the wires of multi-core A.S.P.C. cables, the usual formulæ for the capacity between parallel conductors are inadequate for the purposes of dimensional design. (See Chap. VII., " The Propagation of Electric Currents," Prof. J. A. Fleming.) The application of first principle considerations to this problem is also rendered difficult by reason of the uncertainties attending the determination of the specific inductive capacity of the compound dielectric, its thickness and the mean distance apart of the wires in the completed cable. Furthermore, owing to the relative closeness of the wires, the usual assumptions as to uniform distribution of the electric charges over the surfaces of the conductors are upset by reason of their relatively great mutual attractions. In practice the determination of the leading dimensions of a cable of a given type containing a given number of circuits of a given gauge and mutual electric capacity is founded upon practical data previously obtained as a result of experience in the manufacture of similar cables. Rational empirical formulæ based upon theoretical considerations and embodying practical data have been evolved for the determination of cable dimensions. The constants of such formulæ take account of the effect of nearness of the wires of the cores, the proximity of the various cores and the effective specific inductive capacity of the air-paper dielectric. Their magnitudes depend upon the type of core, *i.e.*, whether Twin, Multiple Twin or Quad, the thickness, electrical properties and mode of application (*i.e.*, whether longitudinal or spiral lapping) of the insulating paper, the arrangement of the cores into layers, the degree of permissible compression of the outer layers of the stranded cable during the sheathing operations and the atmospheric conditions—hygrometric state and temperature—existing during manufacture. Various design formulæ have been published from time to time. References (6), (18), (19) and (20) apply.

In any particular cable the actual average space per core will depend upon the mutual capacity, the total number of pairs in the cable and upon their arrangement in layers, *e.g.*, whether a one, two, three or four core centre is adopted. The number (a) of unit cores in the centre and the number (n) of succeeding layers in a cable containing a given total number (N) of cores may be arrived at from Tables or generally from the relations:—

$$(3n + a)(n + 1) = N, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

for values of a equal to 2, 3 or 4. If a is equal to unity then:—

$$3n(n + 1) = (N - 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

In some instances in practice, particularly in the case of Twin cables, it will be found that for the values of a and n which exist, the total number of cores calculated from the above is less than the number actually employed. This is because cores additional to those provided for in the above expressions have been added to the outer layers. Some degree of crushing naturally results from this practice. In this connection it may be mentioned that the capacity requirements of Twin cables for subscribers' circuits are not very exacting. The problem in this case is mainly one of maintaining adequate dielectric strength whilst securing the largest number of pairs beneath a given diameter sheath.

The ratio of paper to air space and the actual disposition of the paper with respect to the conductors also influence the magnitude of the average space per core. For this and for the other reasons which have been given, therefore, consideration of the relative economic merits of the various cable types for a specific purpose is perhaps most rational when confined to a comparison of the actual diameters underneath the lead sheath of commercially manufactured cables of the Twin, Multiple Twin and Quad types, containing about the same number of physical circuits of equal mutual electric capacity and conductivity. The figures quoted in subsequent pages in regard to this aspect of telephone cables are, except in regard to those for the J.H. type, based upon such a comparison of British manufactured 40 lb. conductor cables. Such figures have definite limitations, inasmuch as that for the purpose of a valid comparison adjustments have been made in the dimensions of the various types considered, on account of their differing mutual capacities. Thus, whereas the modern M.T. cables selected for the comparison averaged 0.062 microfarads per mile and were characterised by small circuit deviations, the Twin cables were of about 0.065 microfarads per mile, with large circuit deviations. The average mean mutual capacity of the Star Quad cables, so far manufactured in this country, is in the neighbourhood of 0.068 microfarads per mile. In making the adjustments the approximate relation expressed by:—

$$D = A\sqrt{N}10^{\frac{B}{C}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

has been used. D is the diameter of the cable core, C the mutual capacity of, and N the number of pairs. A and B are constants for similar cables of the same type and construction and of the same gauge conductor, whose mutual capacities do not differ by more than about 10%. The application of the relative figures obtained in this manner must, of course, be restricted to the general discussion of the relative economic merits for specific purposes of the various cable types.

Classification of Cable Circuits.—A.S.P.C. cable circuits are usually divided into three main classes in accordance with their respective functions in the cable network of a telephone system. The leading technical requirements of each class of circuit are stated below, together with the main general features governing the type of cable to be utilised in each case.

C.B. Subscribers' Circuits.—For Common Battery subscribers' circuits adequate conductivity of the loop as well as high resistance and electrical strength of the insulating medium are the main considerations; mutual electric capacity, inductance and leakance, provided of course that they are not of abnormal value, being relatively unimportant. Such simple requirements are easily secured by the use of cables, the materials of which conform to the usual standards. In addition, these and other desirable features are ensured in the manufacturing stage by effectively insulating each wire and by utilising the smallest possible space for each circuit, consistent with dielectric strength, reasonable freedom from interference and ease of handling during constructional operations.

Twin cables have in the past been exclusively utilised for this service. The reason for this is probably to be found in the circumstance that at relatively large values of mutual capacity, a very much greater degree of freedom from interference between adjacent circuits is obtainable than in other types. Since over a fairly wide range the magnitude of the circuit capacity is of little importance in this case, the advantage of the consequent permissible decreased diameter of such high capacity Twin cables has been utilised. Such cables, at least for capacities in excess of about 0.07 microfarad per mile also appear to be superior to four-wire core cables of equal mutual capacity, from the point of view of dielectric breakdown voltages. For equal pair circuit capacity up to about 0.07 microfarad per mile the Star Quad cable, although at present generally inferior to the Twin type in respect of interference between side circuits, is superior to it in regard to space, 30% or more additional pairs being available for a given diameter cable. Such cables have accordingly a distinct advantage in regard to manufacturing cost per circuit, since for the provision of a given number of physical circuits a smaller diameter Star Quad cable could be utilised, than if the requirement were met by either the Twin or M.T. types. Such types for equal side circuit mutual capacity would be from 12% to 18% larger in diameter.

The superiority of Star Quad cables over the Twin type, in regard also to earth balance of the circuits furnishes another reason for the use of such cables in those cases where interference from earthed circuits of any description is to be apprehended. In regard to constructional costs, a measure of wire-to-wire capacity balancing of the Quad cable as at present manufactured would be necessary in order to reduce the interference between associated side circuits of the quads, to the same average value as exists between adjacent pairs in Twin cable.

Junction and Short Trunk Circuits.—For loaded junction and short trunk circuits the magnitude of the average attenuation (β) per unit length, and the characteristic impedance (Z_o) at the mean speech frequency, are the leading features. Provided the leakance is normal, *e.g.*, a value for the dielectric damping constant G/C of between 15 to 25, such values of β and Z_o will be governed by the equivalent uniform average magnitudes per unit length of the capacity (C farads, mutual wire-to-wire of the line), the resistance (R ohms, loop, line and loading coils) and the inductance (L henries, loading coils and line) of the circuits. For cable of normal design, loaded in accordance with the standard schemes, speech transmission over such commercial circuits may be computed on the assumption that they are electrically uniform and homogeneous or smooth, in which case and assuming half loading section cable terminations, Z_o and β are approximately given by:—

$$Z_o = \sqrt{L/C}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\beta = \tfrac{1}{2} R \sqrt{C/L} = \tfrac{1}{2} (R/L) \sqrt{CL} = R/2Z_o. \quad (5)$$

at least so far as the transmission of currents of frequency necessary to intelligibility in such cases is concerned. The factor R/L of the expression for β may be regarded as the conductor damping constant and includes the damping of the line and loading scheme. The factor involving the dielectric damping constant has been omitted from equation (5) for reasons previously given.

For the transmission of currents of frequency outside this range the line cannot be regarded as smooth and the characteristic of a coil loaded line of "cutting off," or of enormously attenuating currents of frequency above a certain value, must be taken into consideration.

The value of β for a circuit would appear from (5) to depend upon the ratio of C to L for that circuit; this is true only if the actual values of C and L are of such magnitude as to ensure that the frequency band which it is desired to transmit with an average attenuation of β is well within the band beyond which "Cut-off" occurs. The frequency (f_o) of cut-off is given by:—

$$f_o = 1/\pi \sqrt{L_1 C_1}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where L_1 is the inductance of individual coils loading the circuit and C_1 is the total capacity of the cable section between two loading coils. Its actual magnitude is of considerable importance since, amongst other features, it imposes the limit for the usefully transmitting frequency range of the circuit. The ratio of any transmitted frequency (f) to the cut-off frequency is of frequent occurrence in what follows, and for convenience will subsequently be referred to as w, thus:—

$$w = \pi f \sqrt{L_1 C_1}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

From the foregoing it will be understood that equations (4) and (5) are valid only in so far as cable capacities of normal value are employed and the usual standard loading schemes in regard to coil inductance and spacing are not departed from. Furthermore they apply only to frequencies which are well within the cut-off, and for which the energy losses in the dielectric are relatively unimportant. The loading schemes referred to have of course been evolved as a result of the above considerations.

For equal attenuation (β) of side and phantom circuits of a four-wire core, the loading coil inductances, cut-off frequencies and wave-length constants of the respective circuits will be related each to each, in a manner depending upon the magnitude of the phantom to side circuit capacity ratio (P/S). Similarly for loading coil inductances and attenuation as well as characteristic impedances in the case of equal cut-off frequencies and wave-length constants of such circuits. These relations, for frequencies within the cut-off, are given in Table No. IV. in a general form and also in a numerical form for the general average case of M.T. and Star Quad type cables.

As far as the line only is concerned, the requirements of junction and short trunk cables, additional to those of Subscribers' cables, relate to a sufficiently small average value of electrostatic capacity of the circuits consistent with space occupied and electrical stability of make-up, and to small loss in the dielectric, *i.e.*, low power factor ($G/2\pi fC$). This latter feature has been assumed in the approximate expression for β given in (5). In addition, a degree of electrical balance of the circuits superior to that of the previous case is required in order to counteract the augmenting effect of the loading upon the interference between the circuits. Furthermore, if phantom circuits are to be worked, a cable type which is essentially free in the manufacturing stage, from interference between its phantom circuits must be utilised, since it is not at present practicable to arrange for the systematic elimination of such interference during the constructional stage of the work. Finally, similar type circuits in the same cable should preferably have essentially the same average electrical constants, in order that they may give similar performance; with modern manufacture of the M.T. and Quad types, no special steps require to be taken to ensure this feature to the degree which is adequate for this case.

TABLE No. IV.

THE LOADING OF SIDE AND PHANTOM CIRCUITS OF TELEPHONE CABLES.

Loading design.	Circuit characteristics.	Side Cct.	Phantom circuit.		
			General Case.	M.T. Case.	Star Quad Case.
For equal attenuation of side and phantom circuits.	Loading	L	$LP/4S$	$0.41L$	$0.66L$
	Attenuation constant ...	β	β	β	β
	Wave-length constant ...	a	$aP/2S$	$0.82a$	$1.32a$
	Cut-off	f_0	$f_0 2S/P$	$1.22f_0$	$0.76f_0$
	Impedance	Z_0	$Z_0/2$	$Z_0/2$	$Z_0/2$
For equal cut-off of side and phantom circuits.	Loading	L	LS/P	$0.61L$	$0.38L$
	Attenuation constant ...	β	$\beta P/2S$	0.82β	1.32β
	Wave-length constant ...	a	a	a	a
	Cut-off	f_0	f_0	f_0	f_0
	Impedance	Z_0	$Z_0 S/P$	$0.61Z_0$	$0.38Z_0$

Multiple Twin cables have in the past been extensively used for this purpose. Disregarding the availability of its phantom circuits, the M.T. type meets the whole of the electrical requirements in so complete a manner as to offset any slight advantage in respect of manufacturing cost per circuit of ordinary Twin cable. On the other hand the economic advantages of Star Quad cables in this connection become of extreme importance. For the provision of a given number of physical circuits an approximately 15% larger diameter would be required for a M.T. cable than for one of the Star Quad type. With lead sheathed, armoured cables such as are extensively used on the Continent of Europe an even greater reduction in the cable price per pair, than in the case of the lead sheathed cables laid in earthenware ducts in this country, would result from the use of Star Quad cable. The economic gain resulting from the use of Quad cables for junctions and short trunks is minimised only very slightly by reason of the superior capacity balance of the factory lengths of M.T. cables, since a measure of field balancing of the associated pairs would be resorted to in the constructional stages of either type.

The commercial loading of side and phantom circuits is based upon equal cut-off (this involves equal velocity of propagation within the cut-off) for each. From Table No. IV. it will be seen that this entails in M.T. cables, an inductance for the phantom coil of about 0.61 times that of the side coil; an 18% smaller attenuation and consequently a superior phantom circuit of characteristic impedance 39% smaller than that of the side circuit resulting. In order to obtain equal cut-off for the circuits of Star Quad cables, a phantom coil of inductance about 0.38 times that of the side coil must be used. The attenuation of such a phantom circuit would be about 32% greater than, whilst its characteristic impedance would be 62% smaller than that of the side circuit. An increase of inductance of the phantom coil in this case, with a view to improving the attenuation of the lower frequencies, would result in a reduction in the cut-off frequency. For example, the use of standard M.T. loading units for Star Quad cables would result in a cut-off frequency for the phantom circuit, about 21% smaller than that of its associated side circuit, whilst its average attenuation over the lower frequencies of this decreased transmitting range would be about 4% greater, and its characteristic impedance 52% smaller.

As a result of the above considerations, it seems to have been generally concluded that phantom circuit working in Star Quad cables is quite out of question. In this connection the availability of such circuits—of the same cut-off frequency as the side circuits, but of 32% greater attenuation per unit length—for either an overall lower grade circuit or a shorter equally efficient circuit, for use between intermediate stations, should not be lost sight of when dealing with the economics of the case.

Assuming side and phantom circuit working in M.T. cables, but side circuit working only in Star Quad cables then for the provision of a given total number of circuits by means of a M.T. cable, a smaller diameter could be utilised than if the requirement were met by the Star Quad type. The Star Quad type would be about 7% larger in diameter and would require 50% additional conductors. The same total number of loading coils would of course be required in the two cases, although for the M.T. circuits one-third of the total number would be of the more expensive phantom type. Furthermore, transformers to the number of four-thirds of the total circuits, as well as additional apparatus for any special signalling system which may be utilised, would be required for use at the terminals of the M.T. cable. Owing to the increase of resistance of the side circuits of the M.T. core by reason of the inclusion of the phantom circuit coils, equal attenuation of the side circuits in the two cable types would be ensured by something less than a 50% additional weight of copper in the Star Quad type. The choice of M.T. or Star Quad cable in this case would be determined mainly on economic grounds, in respect of which only the more obvious features have so far been dealt with. The question of the greater convenience of side circuit working as well as considerations relating to fault maintenance of the two cable types should also affect the choice.

Assuming that the spiral four cable is actually superior to the M.T. type from the point of view of manufacturing cost, it would appear from the foregoing that this advantage, as well as that of greater uniformity of mutual capacity, could be most economically secured in the general case by the use of this type in the form in which its phantom circuit can best be utilised, *i.e.*, in the J.H. Quad form. For a given number of circuits provided by M.T. and J.H. Quad types respectively, the latter type cable would perhaps be slightly smaller in diameter than the former, and might therefore show some economic advantage on this account also. As an offset to this feature, the Quad phantom circuit would be inferior to the M.T. phantom circuit owing to its somewhat greater mutual capacity.

Long Distance Repeatered Circuits.—For a coil loaded circuit the complete expression for characteristic impedance(21) is less simple than that given in equation (4). It contains resistance and reactance components, the magnitudes of which are dependent upon the length of the end cable section and upon frequency. The complete expression is necessary for the purpose of calculations relating to long-distance circuit working. If the length of cable situated between the end of the line and the first loading coil, expressed as a fraction of a normal loading section length, be equal to x, the resistance (A) and reactance (B) portions of the characteristic impedance, at a frequency f are given by(22) :—

$$A = \sqrt{(1 - w^2)\,L/C} \,/\, [1 - 4x(1 - x)w^2]. \quad \ldots\ldots(8)$$

$$B = \sqrt{L/C}\,(1 - 2x)w \,/\, [1 - 4x(1 - x)w^2]. \quad \ldots(9)$$

It can be shown from these expressions that the resistance component will continually increase or decrease with increase of frequency up to the cut-off according to the value of x. The reactance component will behave in a like manner, except that whereas A shows a falling characteristic for values of x from zero up to 0.17, a practically constant value at 0.17 and a rising characteristic for values above 0.17 and up to 0.83; B shows a positive and rising characteristic for values of x from zero up to 0.5, a practically zero value at 0.5 and a negative and falling characteristic for values of x beyond 0.5. For a value of x equal to 0.5, *i.e.*, with a half section termination, the effective resistance increases with frequency to a very large value in the neighbourhood of the cut-off, whilst as already stated the reactance has practically zero value over that frequency range. The characteristic impedance in this case at a frequency f, may be written :—

$$Z_0 = \sqrt{(1 - w^2)\,L/C}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

When referring subsequently to the characteristic impedance of the line, a half section termination will be assumed and Z_o will have the value given in equation (10).

The complete expression for the attenuation per unit length of a coil loaded line to currents of frequency f is given by :—

$$2\beta = \left[\left(R - \frac{2}{3}w^2 r\right)\sqrt{C/L} + G\sqrt{L/C} \right] \Big/ \sqrt{(1 - w^2)}. \quad \ldots(11)$$

$$\text{or } \beta = \frac{\left(R - \frac{2}{3}w^2 r \right)}{2Z_o} + \frac{G Z_o}{2(1 - w^2)} \quad \ldots\ldots\ldots(12)$$

where R, L, G and C represent the same quantities as in equation (5), and r is the loop resistance per unit length of the conductor only.

It will be evident that unless f_o is considerable, the attenuation of the higher speech frequencies will be much greater than that of the lower, and that generally the smaller the magnitude of the cut-off frequency the greater will be the rate of change (*i.e.*, of increase) of attenuation with frequency. For long circuits the accumulative effects of attenuation distortion (*i.e.*, of the differing degrees of attenuation of the various frequencies transmitted) per repeater section is a serious matter and in such cases it is necessary to ensure a high cut-off. Since, however, with the standard loading schemes, the higher the cut-off, the greater the actual magnitude of the attenuation at any particular frequency, the amplification in very long repeatered circuits must be greater and they will, for this reason and also from considerations of repeater stability, require to be of the four-wire type. In reference to the latter statement it may be deduced from (6) and (11) that :—

$$\beta = \frac{\pi R C_1}{2} \times \frac{\left(f_o^2 - \frac{2}{3}\frac{r}{R}f^2\right)}{\sqrt{(f_o^2 - f^2)}} \quad \ldots\ldots\ldots(13)$$

For long trunk circuits employing telephonic repeaters, the reduction of attenuation of the transmission line is of lesser importance than the actual overall quality of transmission. This matter of quality constitutes in fact the chief problem of long distance transmission; it involves not only attenuation-distortion but also phase-distortion.

The differing velocities of propagation of currents of different frequency, the duration and its variation with frequency of the building-up time of the received current to its steady state value, as well as the actual rate of building-up of the current near to or at the final steady state value, govern the question of phase-distortion. In regard to these latter features, a circuit, which from the point of view of the steady state condition is essentially distortionless, may be very unsatisfactory from the point of view of the quality and intelligibility of the received speech. References (21) to (28) apply.

The design of the loading scheme in relation to the design of the cable directly controls distortion in a long distance circuit, and hence the cable requirements for such networks cannot be considered without reference to the loading system. In all cases the cut-off frequency must be maintained at a high value, not only for the reasons already given but particularly for the purpose of minimising the " transients." The adverse auditory and psychological effects of " echo " can be eliminated by the use of " echo suppressors." With the relatively low inductance and closely spaced coils of the " Half Medium Heavy " or " Extra Light Heavy " loading schemes, a sufficiently high cut-off for circuits up to eight or nine hundred miles in length, equipped with various apparatus auxiliary to the repeaters, is secured by the use of normal capacity cable, at least as far as the side and phantom circuits of M.T. cables are concerned. The relatively high capacity of the phantom circuits of Star Quad cables gives rise to difficulties which have already been pointed out in the section relating to junction and short trunk working. This same feature is, however, of so much greater importance in regard to the above aspect of long-distance networks that as far as present-day practices are concerned the use of such circuits is precluded.

The mean attenuation-frequency ($\beta - f$) and impedance-frequency ($Z_0 - f$) characteristics over the designed transmitting range, as well as the extent of the deviations of the actual $\mathbf{Z}_0 - f$ characteristics from their mean values, constitute criteria for two-wire repeatered circuits. Such circuits are accordingly required to be uniform in respect of their electrical constants, not only as far as the average values per unit length for similar circuits are concerned but also and particularly in regard to distribution along the length of such circuits. The reasons for this have already been given. In this connection it should be observed that neither a technical nor an economic advantage results from an extreme degree of length uniformity, since the attenuation length of the cable between repeater stations and the repeater gains are limited in practice by the control which it is necessary to exercise upon the power levels along a circuit on account of interference difficulties. The factory lengths of modern high grade M.T. cables are very uniform, but it is probable that the higher amplification possible with a more uniform cable, working in conjunction with two-wire repeaters of suitable impedance, could be effectively utilised.

Finally the balance of the circuits from the interference point of view will require to be very exact, since only very slight cross-talk can be tolerated in repeatered circuits. The unbalances between the oppositely transmitting circuits (*i.e.,* " Goes " and " Returns ") for four-wire working must be very small and this feature is ensured in the manufacturing stage of long-distance cables, although additional immunity from interference between such circuits is secured by special separation of the cable units into groups during the constructional operations.

General Summary of considerations affecting choice of Cable type.—The technical essentials and the cable requirements for the principal classes of telephone circuit have already been described. These requirements, taken in conjunction with the data previously given in respect of what is possible of achievement in modern commercial cable manufacture, furnish information which directly affects the question of the most suitable type to be adopted for each of the various services. There is another most important feature, however, governing the actual choice of cable type, namely, the cost or economic aspect. (See Chap. XII., " Telephonic Transmission," J. G. Hill). In some cases the economic considerations are quite simple to apply and the determination of the best cable type is a perfectly straightforward matter. In other cases, the question of relative costs is much more complex and a detailed study involving manufacturing and constructional costs of cable and line plant as well as relative maintenance and other costs is necessary before a decision can be made. In this connection consideration should also be given to permissible departures from present-day standard practice, in relation to any economic gains which may accrue therefrom. Such studies will of necessity be based upon costs, which vary not only in different countries but also from time to time in the same country. Decisions arrived at in this manner will accordingly be of neither universal nor perpetual application. In the case of long-distance networks a very large proportion of the total cost of the system is expended in the line and line plant, and the economic aspect of cable type is accordingly of prime importance. Now, frequent changes of cable type in the same system or differences of type in adjoining systems will give rise to considerable technical difficulties. If, therefore, a preliminary study points to the desirability of a change of type, the difficulties introduced thereby will require to be assessed as additional costs and a further study made on this basis. In those cases where the introduction of such difficulties result in an inherent reduction of overall efficiency of the system, they must be obviated, despite the economics of the case. On the other hand, the initial design and lay-out of the system in combination with future developments of the communication art, may permit of any economic advantages accruing from a change of cable type being secured.

Bibliography.—The various sources of information which have been freely drawn upon in the preparation of this article are given grateful reference in the attached bibliography. The data contained in Tables II. and III. has been included by the courtesy of Colonel Purves, Engineer-in-Chief. The author acknowledges with thanks the assistance derived from discussions on the subject of the article with his colleagues both within and outside the Service.

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DESIGN AND STANDARDISATION OF COIL-LOADED TELEPHONE TRUNK CABLES.

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I. THE TYPES OF LOADING EMPLOYED AT THE PRESENT TIME FOR INTERNATIONAL TELEPHONE CABLE CIRCUITS.

TWO methods of loading long-distance telephone cable circuits are recommended by the C.C.I. as being both equally suitable for international circuits. These two methods relate to cable circuits in which the phantoms are used. The following are the main properties of circuits comprised in both systems:—

Type of Loading.	Gauge of Conductors. *mm.*	Type of Circuit.	Capacity. $\mu F/km$.	Length of Loading Section. *km.*	Coil Inductance. H.	Maximum Conductor Attenuation per *km* at 800 p.p.s.	Natural Frequency.
Method I. Medium-heavy ...	0.9	Side	0.0385	1.830	0.177	0.0217	2,900
		Phantom	0.0625		0.063	0.0228	3,600
	1.3	Side	0.0385		0.177	0.0121	2,900
		Phantom	0.0625		0.063	0.0125	3,600
Method I. Extra-light ...	0.9	Side	0.0385		0.044	0.0390	5,800
		Phantom	0.0625		0.025	0.0328	6,000
Method II. Medium-heavy ...	0.9	Side	0.0335	2.000	0.200	0.0197	2,750
		Phantom	0.0540		0.070	0.0210	3,670
	1.4	Side	0.0355		0.190	0.0097	2,750
		Phantom	0.0570		0.070	0.0101	3,520
Method II. Extra-light ...	0.9	Side	0.0335		0.050	0.0307	5,340
		Phantom	0.0540		0.020	0.0350	6,840

In respect to attenuation and natural frequency—the two most important electrical properties as far as transmission is concerned—there is no appreciable difference between the two systems. Such slight differences as occur are manifestly not due to a fundamentally different conception, but rather to the fact that in each method a round figure for the units of length normally used in the countries where the respective systems originated—6,000 feet (= 1830 metres) in America and 2 km. in Germany—has been chosen as the distance between loading coils. Inasmuch as both systems, independently of each other, have led to approximately the same electrical values, we may perhaps assume that the systems corresponded in the fullest measure, at the time when they were designed, with the existing state of knowledge and experience.

In the meantime, cables in which the phantom circuits are not used (so-called " Star Quad " cables), have been laid in Holland. These possess the following properties :—

Type of Loading.	Gauge of Conductors. *mm.*	Type of Circuit.	Capacity. μF/*km.*	Length of Loading Section. *km.*	Coil Inductance. H.	Maximum Conductor Attenuation per *km* at 800 p.p.s.	Natural Frequency.
Medium-heavy	1.0	—	0.0365	1634	0.200	0.014	2,860
	1.0	—	0.0365	1634	0.155	0.015	3,260
	1.6	—	0.0365	1634	0.155	0.008	3,260
Extra-light	1.0	—	0.0365	1634	0.050	0.025	5,800

It is noticeable that in this case a natural frequency has been chosen which lies between the natural frequencies of the physical and phantom circuits of methods I. and II.

The C.C.I. at its last meeting in November, 1926, expressed the opinion that from the technical point of view Star-quad cables are just as suitable for the international telephone service as the Dieselhorst-Martin cable ordinarily used, provided they satisfy the general conditions laid down for factory lengths and repeater sections.

There can be no doubt that it is not desirable to admit for the international telephone service the use of a number of different types of cable. The necessity for examining from time to time the suitability of all types is also generally recognised. The C.C.I. in dealing with transmission questions has therefore proposed to examine the question, amongst others, whether since the time when the two methods of loading referred to above were adopted experience has shown that an alteration in the type of circuit, hitherto regarded as normal, could be made which might lead to a uniform system.

Detailed investigations have lately been carried out in the Central Laboratory of the Werner Works of Messrs. Siemens and Halske with respect to the most suitable system of loading, and it is now proposed to discuss the most important aspects of these researches. We purpose also to examine the requirements of telephone circuits which this investigation has indicated at the present stage of development of telephone technique concerned with the design of long distance circuits. In the light of these requirements, a proposal will be made for the loading of future telephone cables which may perhaps serve as a basis for further discussion.

II. General Aspects of the Selection of the most suitable Type of Loading.

The fundamental object of long-distance telephone engineering is to provide telephone circuits equipped in such a way that the quality of the transmission between any two subscribers at different places is not inferior to the quality of the transmission usually obtained within the area of one and the same town. This is essentially the quality of transmission which corresponds to the electric and acoustic properties of the telephone apparatus itself. It is also required, as in all technical problems, that this object shall be achieved with the minimum cost. In the selection of the most suitable type of loading, therefore, the economic point of view has to be considered as well as the engineering aspect. Telephone engineering at the present time has itself all the means necessary for attaining, to almost any degree of perfection, the object referred to above, even when we have to deal with very long circuits. The higher the degree of perfection, however, the more rapid is the increase in cost. It follows that for every measure contemplated the question must be examined whether the improvement attainable is worth the additional cost involved. In order to render possible such examination and estimation, it is necessary to introduce a measure for the quality of transmission. We employ for this purpose in the following paragraphs the so-called " syllabic intelligibility." This is defined as the ratio of the number of unconnected syllables correctly received to the total number of such syllables which have been transmitted by word of mouth—the whole being arranged on a systematic basis. Strictly speaking, it is true that in telephoning we are generally concerned with the transmission of coherent sentences, so that it would be more accurate to use " sentence intelligibility " as a measure of the quality of transmission. It can be shown, however, that " sentence intelligibility " on the one hand is not so easily reproducible, because the size of the figures representing it depends largely upon the nature of the sentences, upon the themes, and upon the intellectual capacities of the observers. On the other hand, it cannot convey more than " syllabic intelligibility," because, generally speaking, we cannot of course estimate what, for example, is to be interpreted from the fact that, say, one of a hundred sentences has not been correctly understood.

It is also very important in this connection to note whether the conversations on the part of both subscribers have been made in a common mother tongue. Experience has shown that even slight differences of dialect reduce " sentence intelligibility." The difference is still greater with conversations in a foreign language. Although the connection between " sentence intelligibility " and " syllabic intelligibility " is not simple and unambiguous, it is, however, a fact, agreeing with all observations made hitherto, that " sentence intelligibility " increases with " syllabic intelligibility." We are, therefore, quite justified in regarding " syllabic intelligibility " as a practicable measure for quality of transmission.

We now propose to examine the individual factors which affect intelligibility, and thus obtain definite requirements for the design of coil-loaded circuits. Strictly speaking we cannot regard any of these factors as being wholly independent of the others; they have all a mutually dependent relation. For example, the dependence of intelligibility upon the width of the frequency band transmitted cannot be investigated unless, at the same time, the distortion and noises otherwise occurring or the sound volume be taken into consideration. We cannot express an opinion with respect to the necessary volume without premising something with respect to disturbing noises. In the case under consideration, however, we are not concerned very much with stating the precise figure for the quality of transmission finally to be attained, but we can, by considering individual causes and their effect upon intelligibility, deduce some important rules which must necessarily be followed if the object as stated above is to be attained to the greatest possible extent.

The C.C.I. has recommended for a series of properties of telephone circuits definite values which are based on theoretical considerations and practical experience. These are mostly minimum values, as, for example, the permissible overall attenuation, the permissible cross-talk attenuation, and the minimum width of the frequency band to be transmitted. These minimum values are to some extent determined purely by the technical appliances available and will be re-examined as telephone engineering progresses. It is therefore constantly necessary to adapt these values to this progress. We will deal first with volume and the requirements which result therefrom.

(1) *Volume.* The volume at the receiving end of a telephone circuit is determined by the electro-acoustic efficiency of the apparatus itself and by the attenuation of the line system between the sets of apparatus. In the case of the telephone apparatus generally used the efficiency is such that with a line attenuation of $b = 0.5$ to 1.5 we obtain approximately the same volume in the receiver as in the case of normal direct conversation. The intelligibility decreases from this point onwards with increasing attenuation.

If the transmission itself is distortionless and free from interference, the diminution of intelligibility is determined especially by the intensity of the noises in the rooms in which the speaking apparatus has been installed. Fig. **1** shows the relation between intelligibility and line attenuation when ordinary central battery apparatus is used and when room noises on the average correspond to what occurs in practice. The maximum attenuation between two subscribers as recommended by the C.C.I. has the value $b = 3.3$. It will be seen from Fig. **1** that this value in fact must represent the outside limit permissible. Intelligibility in this case is already several per cent. lower than when the attenuation is $b = 2$. It would be desirable, therefore, to go as much below this as possible. This is, however, a question of economics because the costs of large town systems increase rapidly if the attenuation is reduced.

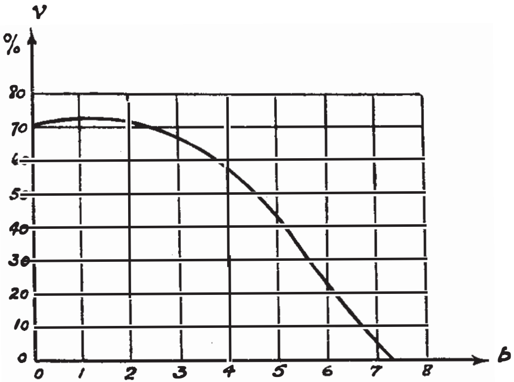


Fig. 1

Dependence of Intelligibility V upon Line-attenuation b

An interesting point for our observations is the question how to distribute most suitably the value of attenuation between the trunk line and the local lines. From a technically operative point of view, it would apparently be desirable that the trunk line itself had no attenuation. The local system could then be designed in accordance with the maximum permissible attenuation, and the volume of transmission within one and the same town area would have in the most unfavourable case about the same value as between any two subscribers in different towns. We have, however, to consider in the first place that the costs of the trunk lines themselves increase as attenuation decreases if we are tied down to definite requirements in respect to quality of transmission.

An important factor in this connection is that echo disturbance under otherwise similar conditions increases with a reduction in attenuation and an increase in the total amplification. Thus Fig. **2** shows how in an ordinary 2-wire circuit with two repeaters the intensity of the " speaker echo " increases if the overall attenuation is reduced.*

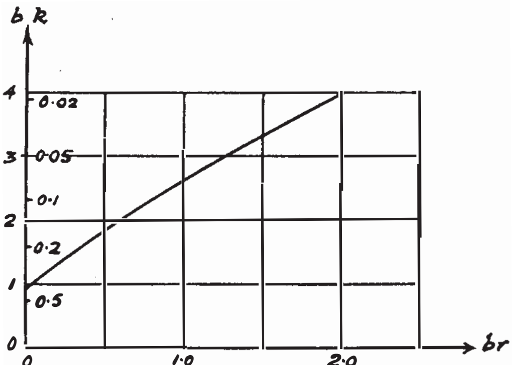


Fig. 2

Dependence of Echo attenuation b and relative Echo strength k upon Overall attenuation br

When dealing with small overall attenuations on telephone circuits, we must, therefore, employ means for reducing echo disturbances either by using echo-suppressors or complicated balancing networks in the compensation circuits, or in order to reduce the transmission times of echo currents by increasing the natural frequency of the line. These means therefore increase the cost of the telephone line in proportion as the overall attenuation of this line is to be reduced. Strictly speaking, we must therefore reduce to a minimum the sum of the costs of the local lines and those of the long-distance lines by suitable distribution of the overall attenuation. This, of course, cannot generally be done. An additional factor here is that with the means at present at disposal both in the case of 4-wire and 2-wire circuits we cannot go below a certain

* *We use the word " echo " for all disturbing phenomena which arise from the fact that portions of the speech currents traverse by-passes with the time lag at the speaker or the listener even if the transmission time is so short that an echo in the lag sense of the term can no longer be perceived, as, for example, in the case of short 2-wire circuits.*

overall attenuation without appreciably reducing reliability of working.

These, therefore, are minimum limits, which experience has confirmed. The C.C.I. has laid down $b = 1.3$ as the minimum value for overall attenuation. In almost all international circuits recently brought into service, efforts have been made and with success to obtain somewhat lower attenuation values. In the present circumstances, a reduction to $b = 1.0$ should generally be quite possible. This figure will therefore be taken as a basis in this paper. The volume of extraneous disturbances—and therefore, of cross-talk and power-current induction—is determined (in addition to transmission volume) by the choice of the overall attenuation. From this relationship definite limiting values are shown in the following section of this paper for the attenuation between two successive repeaters in the long-distance circuits.

(2) *Disturbances.* In consequence of the differences of the transmission level at various points in the long-distance circuit the intensity of cross-talk between two subscribers is generally different from the intensity of cross-talk in cable circuits themselves.

In addition to the speech currents, the induced cross-talk currents are amplified by the repeaters in the circuit. The more the repeater section attenuation is increased, the greater must be the amplification with a given overall attenuation; the more unfavourable, therefore, will be the conditions in respect to cross-talk disturbance. With a given intensity of cross-talk between the cable circuits themselves we must not therefore exceed a certain value of repeater section attenuation if the intensity of the cross-talk at the subscribers' stations is not to exceed a definite amount.

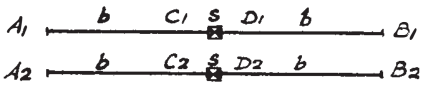


Fig. 3.

Cross-talk in two adjacent two-wire circuits.

We see this in the simplest way by considering two adjacent 2-wire circuits A_1, B_1, and A_2, B_2 (Fig. **3**). When speaking at A_1 and listening at A_2, there are two common paths available for cross-talk currents, the first through the couplings of the two line sections A_1, C_1, and A_2, C_2; the second from A_1 through C_1, repeater to D_1; from there through the couplings of the second line section D_1 B_1 to D_2, through the repeater of the second circuit to C_2 and back to A_2. The second path is here of special interest. The overall attenuation b_n for this part is, according to Fig. **3**,

$$b'_n = b - s + b_n - s + b,$$

if b_n denotes the cross-talk attenuation between the two ends of the line D_1, D_2. For the subscribers A_1 and A_2 we have therefore the cross-talk attenuation

$$b'_n = 2b - 2s + b_n \quad \text{.............................} (1)$$

The amplification s is now determined by the required overall attenuation. According to the foregoing section of this paper this should be 1.0. We must therefore have

$$2b - s = 1.0$$

or

$$s = 2b - 1.0$$

Consequently, from equation (1),

$$b'_n = b_n - 2b + 2.0 \quad \text{..........................} (2)$$

The C.C.I. has recommended the limiting value $b_n = 7.5$ for the cross-talk in long-distance circuits. As is seen by Fig. **1**, this figure corresponds in fact to a volume at which, in normal circumstances, intelligibility practically ceases.

We have therefore

$$b_n - 2b + 2.0 > 7.5$$

With modern telephone cables we may assume that b_n is always greater than 8.5. We thus finally get

$$b < 1.5 \quad \text{..} (3)$$

The attenuation of a repeater section for 2-wire circuits must therefore be less than 1.5 in order that the conditions which have to be laid down in respect to freedom from cross-talk shall be fulfilled. This does not, of course, mean that this value represents a sharp limit which must not be exceeded in any circumstances. As the foregoing deduction shows, the permissible repeater section attenuation depends in great measure on what cross-talk attenuation had been attained in the cables and repeaters. This generally will be greater than the value laid down. The repeater section attenuation depends further upon the value of the cross-talk which is to be required for the whole circuit; this in turn depends upon the intensity of other transmission interference, for example, upon noises. We shall therefore have to regard the value $b = 1.5$ as the attenuation which on the average should not be exceeded. With such a limiting value practicable conditions are also obtained for other inductive disturbances. For example, if in the line section D_2, B_2, noise currents arise from any causes, *e.g.*, from power supply installations, having a noise voltage V, we have at C_2 a noise voltage Ve^s. The subscriber at A_2 will therefore hear noises of intensity

$$V' = Ve^{s-b}.$$

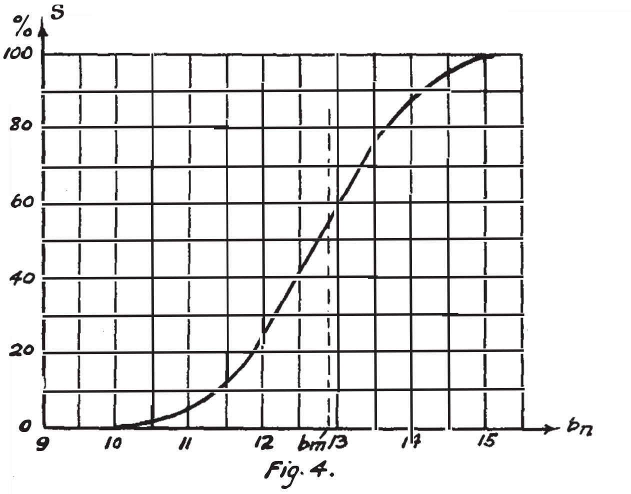


Fig. 4.

If we put here as we have already done

$$s = 2b - 1 \text{ and } b < 1.5$$

it follows that

$$V' < Ve^{0.5}$$
$$V' < 1.7 \times V.$$

The noise disturbance in practice is not, therefore, appreciably greater at the subscriber's apparatus than it is directly on the lines.

The same conditions apply to 4-wire circuits. In this case the circuits are separated in the usual way into two equal and opposite parts for speaking in both directions. In this manner higher cross-talk attenuations between cable circuits are obtained than in 2-wire circuits.

Figs. **4** and **5** thus show the extent of cross-talk attenuation between speech circuits in both equal and opposite directions in a modern cable. The curves have been obtained on half a repeater section, so that approximately $b = 1.3$ must be added to the attenuation values (far-end cross-talk) shown in Fig. **5**. The average values then amount to:

$b_m = 12.9$ for cross-talk between speech circuits in opposite directions, $b_m = 13.8$ for cross-talk between speech circuits in the same direction (far-end cross-talk) and in practice all attenuation values of near-end and far-end cross-talk exceed $b_n = 10.5$.

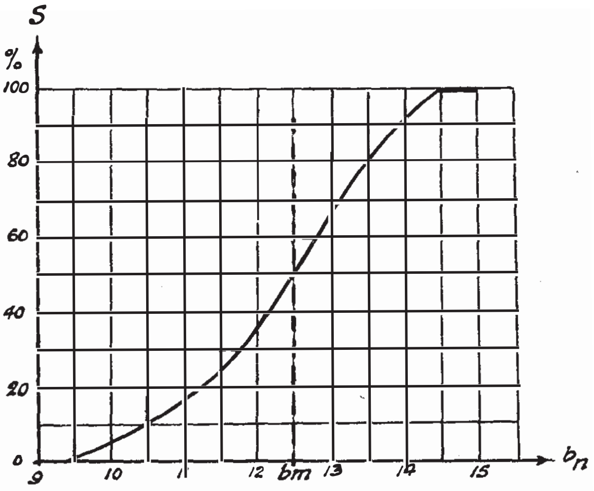


Fig. 5.

According to Fig. **6**, we have, in the case of 4-wire circuits, as above,

$$b'_n = 2b^0 - 2s + b_n \quad \text{.........................(4)}$$

The amplification s chosen must be so great that

$$b_1 - s + b - s + b_1 = 1.0$$

or

$$s = b_1 + \tfrac{1}{2}b - \tfrac{1}{2} \quad \text{..............................(5)}$$

If we insert this in equation (4) it follows that

$$b'_n = b_n - b + 1.0 \quad \text{............................(6)}$$

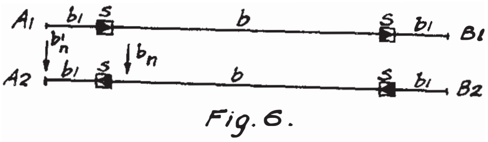


Fig. 6.

Cross-talk in two adjacent four-wire circuits.

At this point we must remember that in 4-wire circuits we have to deal for the most part with circuits of great length in which many successive repeater sections are inserted. The cross-talk currents in each of the sections have then to be added, which according to measurements and theoretical considerations thus reduce cross-talk attenuation by 0.3 to 0.5. We have then, approximately,

$$b'_n = b_n - b + 0.5.$$

If, again, we put

$$b'_n >= 7.5. \text{ and } b_n = 10.5,$$

we obtain

$$b. < 3.5 \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The average attenuation of a repeater section should therefore amount to as much as 3.5. This is appreciably more than is permissible in present day practice. It has, however, to be considered that with telephone cables equipped with repeaters the line costs are, of course, reduced as the repeater section attenuation increases, that, however, the repeater costs themselves rise with the necessary amplification and especially if an additional repeater valve is necessary. These economic considerations will induce us to adopt a lower limit—a limit appreciably below that given in equation (7). Even in respect to other inductive disturbances, for which the same considerations apply as for 4-wire circuits, it appears to be desirable not to take advantage of this limit to the full. Further important aspects of the calculations made for telephone cable circuits arise from the consideration of distortion, that is, those disturbances which the transmission system, as such, provokes.

(3) *Distortion.* Long-distance circuits from an electrical point of view are distinguished from short local circuits particularly by the fact that they transmit a limited frequency band. The C.C.I. recommends the transmission of the following ranges of frequency :—

2-wire Circuits	300—2000 p.p.s.
4-wire Circuits Medium-heavy loaded.	300—2000 p.p.s.
4-wire Circuits Extra-light loaded.	300—2500 p.p.s.

Fig. 7 shows what effect this restriction of the frequency band emitted from the transmitter has upon intelligibility. The intelligibility values have been arrived at with normal central battery apparatus over a distortionless line with attenuation $b = 1.0$. Frequencies below 300 p.p.s. have been eliminated by means of a high-pass filter. The upper limit of the frequency range of transmission is represented by the abscissæ. For purposes of comparison, a curve made by H. Fletcher, which applies to distortionless transmitting and receiving apparatus, is also reproduced. In the case with which we are dealing, however, we are concerned with values obtainable with commercial apparatus.

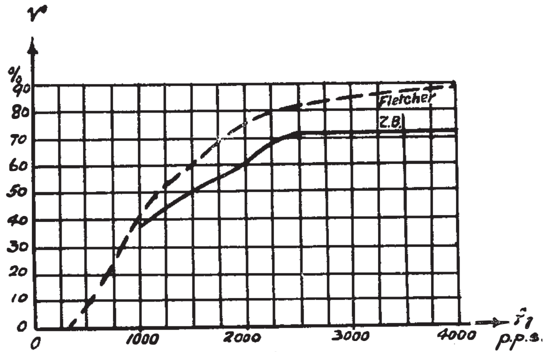


Fig. 7.

Dependence of Intelligibility r upon the higher limit f1 of the transmission range.

The following values of intelligibility have been obtained with the frequency range referred to above :—

Type of Circuit.	Frequency Range	Intelligibility.
2-Wire Medium-heavy loaded.	300–2000 p.p.s.	59%
4-Wire ,, ,,	300–2200 ,,	64%
4-Wire Extra-light loaded.	300–2500 ,,	71%

It will be seen that even slight differences in the width of the frequency band have considerable effect upon intelligibility. The employment, even at the present time, of such different widths of frequency band is due to the fact that, with a given type of circuit, every extension of the frequency band transmitted involves an increase in other disturbances, for example, echos in 2-wire circuits or so-called "phase distortion." Experience has now provided data for definite frequency ranges at which transmission efficiency is greatest, applicable to to every type of circuit and for all distances with which we are able to cope in practice. These are precisely the ranges given above. This explains the apparent arbitrariness in the requirements for various types of circuit. The large differences in transmission efficiency of telephone circuits to which this gives rise are, however, no longer justified for the future. It must be required that in all circuits at least the frequency range shall be transmitted within which the oscillation components of the speech currents, which determine intelligibility, are comprised. To exceed this would, moreover, be uneconomical, as every extension of the frequency range involves an increase in natural frequency and therefore enhances the cost of the plant. Fig. **7** shows that an increase of the high limit of the transmission range beyond 2,400 p.p.s. gives only a slight increase in intelligibility, and that in this case, therefore, the maximum transmission efficiency has practically already been obtained. Transmission within a range of frequencies up to 2,400 p.p.s. sounds more natural, even from the observer's point of view, than within a band up to only 2,000 p.p.s. The lower limit of the transmission range has very little influence. An increase from 300 to 400 p.p.s. causes only a small percentage reduction in intelligibility. On the other hand, practically no difference has been found between transmission when the lower limit of frequency is unrestricted and when the latter is limited to 300 p.p.s. The following fundamental requirement therefore results :—In all circuits the same band of frequencies shall be transmitted; this range shall be between 300 and 2,400 p.p.s.

In conjunction with this stipulation some further requirements have to be considered; these are based on phase distortion and echo disturbances.

A measure for phase distortion is afforded by the "building-up time" of the alternating currents. This is determined by the difference in the transmission time for the single frequencies. The nearer frequencies transmitted approach the natural frequency of the line, the longer is the duration of the "building-up" phenomena and the greater, therefore, is the alteration in the acoustic formation, and therefore, also the greater is the reduction in transmission efficiency. A natural frequency must, therefore, be selected which is sufficiently high to impose a certain higher limit on the highest frequency to be transmitted, and this limit depends upon what reduction in transmission efficiency may or can be permitted.

The manner in which the acoustic character of the volume of speech is disturbed by phase distortion will be seen from Fig. **8**.

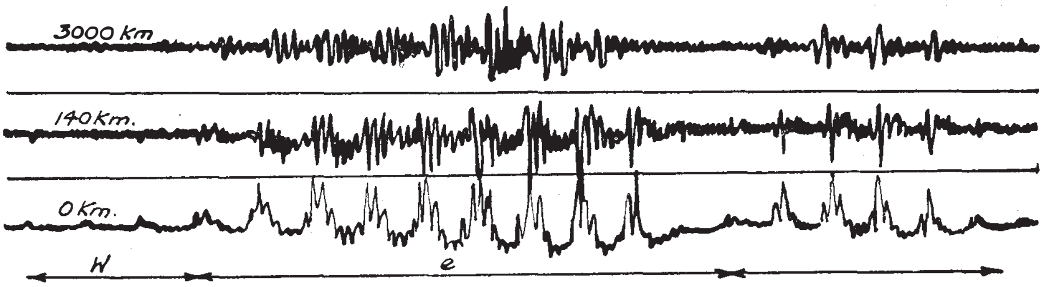


Fig. 8.

Effect of phase distortion upon character of sound.

This shows an oscillogram of the word "wer" at the beginning of a medium-heavy loaded long-distance line (lower curve); behind the first repeater, *i.e.*, at about 140 km. (centre curve); and at a distance of 3,000 km. (upper curve). It will be seen how strongly after the first repeater section the fundamental oscillations are weakened in comparison with the higher oscillations by the restriction of the frequency band, and how, further, volume formation itself appears to be, to some extent, changed by phase distortion. At 3,000 km. we find only slight similarity to the signals transmitted. With such a length the "building-up time" for the highest frequency transmitted is about 100 milliseconds. It is, however, astonishing that even with so pronounced a distortion a comparatively large amount of what is spoken is intelligible. Fig. **9** shows the dependence of intelligibility upon " building-up time " for the highest frequency transmitted, viz:—the frequency $f = 2100$ p.p.s. With small " building-up times " the intelligibility corresponds roughly with the frequency band transmitted. At 10 to 15 milliseconds it falls off by about 1 to 2% ; it then falls gradually and at 100 milliseconds amounts to about 50%. It must, of course, be noted in this connection that even from about 20 to 30 milliseconds the speech transmitted is accompanied by incidental sounds, of which the volume and duration increase with increasing " building-up time," and cause more and more disturbance to the listener. This phenomenon is particularly disturbing from about 50 milliseconds upwards. It is then somewhat similar to the disturbance which is felt by the presence of a strong listener-echo in short circuits. It follows from these observations that it would be desirable to make the " building-up times " in long-distance circuits somewhat less than 10 to 15 milliseconds, and on the other hand to avoid entirely " building-up times " beyond 30 to 40 milliseconds. On account of the similarity of the disturbances caused by phase distortion to echo disturbances, the latter must be taken into consideration in the final choice of one of these figures for the " building-up time."

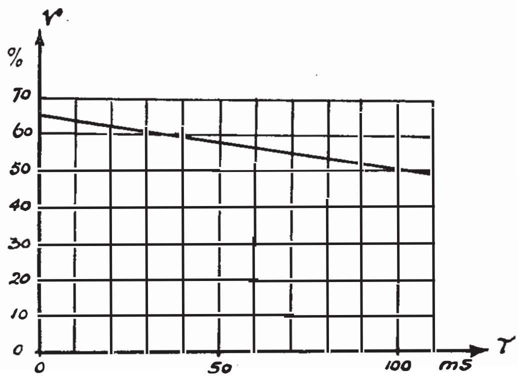


Fig. 9.
Dependence of Intelligibility V upon building-up time T.

4-Wire circuits are practically free from echo disturbances with the use of echo-suppressors; the latter suppress all echo-effects which are due to compensation arrangements at the ends of the circuit. Only a portion of the echo-currents persist, these being caused by cross-talk between the " go " and " return " lines. We have premised above that the attenuation of these cross-talk currents is greater than $b = 7.5$. When they are of this value they are practically no longer perceptible. In 4-wire circuits, therefore, the phase distortion constitutes the only disturbance to transmission efficiency; this increases with the length. In this case we can, therefore, permit somewhat longer " building-up times."

In 2-wire circuits, on the other hand, the elimination of echos is not possible by simple methods. In a 2-wire circuit having n successive repeaters we have to consider n principal echo paths for the speaker and $\frac{n}{2}(n - 1)$ for the listener. The listener-echo therefore increases appreciably as the length of circuit increases. The amplitude of the echo is chiefly determined by variations in the impedance of the lines. These variations are again dependent upon the distance of the frequency in question from the cut-off frequency, and, of course, they increase on the average as the cut-off frequency is approached; this is shown in Fig. **10**. It cannot generally be stated how great are the variations themselves, because they are mainly dependent upon unavoidable incidental circumstances, for example, upon the necessity of making one loading section somewhat longer or shorter than the others. In order to attain adequate reliability, the cut-off frequency f_0 must therefore be sufficiently high. The curve in Fig. **10** shows that from about $f/f_0 = 0.7 - 0.75$ upwards echo disturbances increase materially. It is, therefore, politic not to exceed this limit. In conjunction with the figures laid down above for the frequency range transmitted, this means that the cut-off frequency of 2-wire circuits should not be below 3,200 to 3,400 p.p.s. Further, on account of the additional echo disturbance the permissible " building-up time " is put somewhat lower than for 4-wire circuits. In accordance with the foregoing, 10 to 15 milliseconds for 2-wire circuits and 20 to 30 milliseconds for 4-wire circuits are regarded as suitable limiting values for the " building-up time."

The well known formula for the relation between "building-up time" and cut-off frequency serves for determining the latter itself. This relation is shown in Fig. **11**.

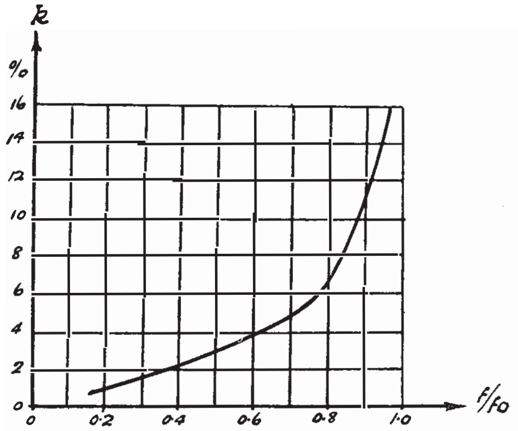


Fig. 10.

Dependence of relative echo strength, k, upon the ratio f/f_0 of frequency transmitted to cut-off frequency.

In this l denotes length of line, s length of loading section, f_1 the maximum frequency to be transmitted, t the "building-up time," f_0 the cut-off frequency. If, for example, $s = 2.0$ km., $f_1 = 2{,}400$ p.p.s. and t 0.01 milliseconds, and $l = 600$ km., then $\frac{l}{s f_1 t} = 12.5$. and according to Fig. **11** $f_0/f_1 = 1.45$. The cut-off frequency f_0 must in this case therefore amount to 3,500 p.p.s. For a circuit 5,000 km. long $\frac{l}{s f_1 t}$ would be equal to 104; therefore according to Fig. **11** $f_0/f_1 = 2.6$. The cut-off frequency must be at least $f_0 = 6{,}200$ p.p.s.

In this manner the lowest cut-off frequency, which is necessary for attaining the desired transmission efficiency, could be determined for every length of circuit. It is at once seen that such a method is not applicable in practice. We must be content to employ only a few types of circuit. How such types of circuit can be most suitably selected will be examined in the next section of this paper. In respect to distortion, we have so far considered only the so-called linear distortions. In addition to these, as is well known, transmission disturbances occur by reason of the fact that the electrical properties of the various parts of the long-distance circuits depend upon strength of current. Non-linear distortions have, however, no effect upon the questions under consideration because they can be reduced sufficiently by suitable construction of repeaters and lines.

III.—Cut-off Frequency and Repeater Section Attenuation.

If a coil-loaded circuit is to have a definite cut-off frequency and a definite attenuation, all other dimensions, for example, gauge of conductors, length of loading section, etc., must be deduced from the requirement that both these required properties shall be obtained at minimum cost. We have, therefore, first to lay down the cut-off frequency and the attenuation values between any two successive repeaters.

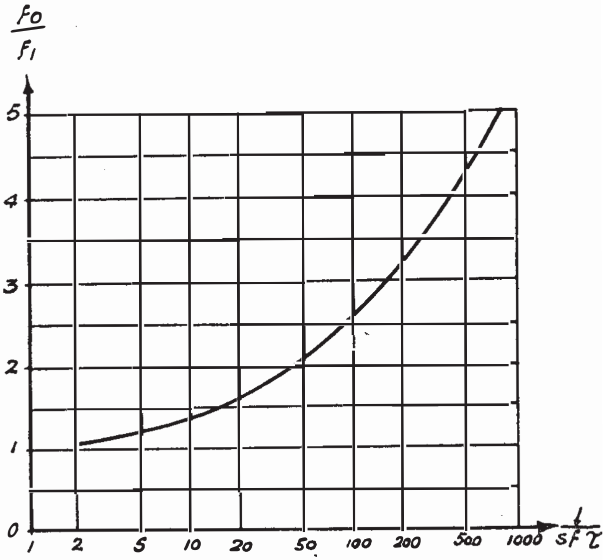


Fig. 11.

Determination of cut-off frequency.

(1) *Cut-off frequency.* On 2-wire circuits it has been stated above that the cut-off frequency should be greater than 3,200 to 3.400 p.p.s. For the greater of these two figures $f_0/f_1 = 1.42$; hence, according to Fig. **11** $\frac{l}{s f_1 t} = 11$.

If we put $f_1 = 2{,}400$ p.p.s., $t = 0.01$ up to 0.015 seconds, $s = 2$ km., we obtain $l = 530$ to 800 km.

If the phantom circuits are to be brought to the same attenuation as the side circuits, we obtain a cut-off frequency of $f_0 = 4{,}200$ p.p.s., corresponding to a maximum length of circuit of 1,200 to 1,800 km. For the side circuits, therefore, we get an average range of about 650 km. and about 1,500 km. for the phantom circuits. In the present state of telephone engineering, 2-wire circuits do not enter into consideration for long distances. On the other hand, these circuits are of great practical importance by reason of the fact that they are appreciably cheaper than 4-wire circuits. It must not be overlooked that the maintenance of 2-wire circuits demands increased care and attention, and that perhaps also the uniformity obtained for new lines, on installation, cannot be fully maintained. It appears at the present time, however, that we are not justified in treating them as of less importance than 4-wire circuits. For this reason, in the foregoing paragraphs the same range of frequency has been presupposed for 2-wire circuits as for 4-wire circuits. If this frequency range is to be transmitted for the longest possible distances, it is necessary in accordance with the foregoing considerations to fix the cut-off frequency at about 3,400 p.p.s. To exceed this would only afford a slight advantage while unnecessarily increasing the cost of plant.

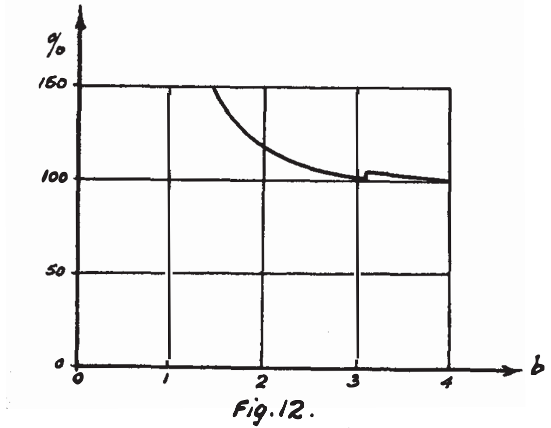


Fig. 12.

Dependence of costs of a four-wire circuit upon repeater section attenuation.

The decision in respect of 4-wire circuits is somewhat more difficult because we cannot with safety overlook the question of the lengths which mainly enter into consideration. It would meet the object in view to select two cut-off frequencies for the side-circuits; one for the maximum lengths of circuits which have to be dealt with and the other for moderate distances as has been done in Methods I. and II. recommended by the C.C.I. In these two methods of loading, the cut-off frequency for extra-light loading is selected to be of such dimensions that the length of repeater sections are half as great as with medium heavy-loading. We should recommend that this principle be adhered to, because in this manner all 4-wire circuits may have conductors of a single gauge. The ratio between cut-off frequencies of extra-light and medium-heavy loading in this case is approximately 2.1. If the maximum length is given for one of these two types of circuit up to which it is to be applicable, we can immediately calculate the cut-off frequency, because the " building-up time " is already determined. The cut-off frequency for the other type of loading is self-evident. For the phantom circuits we then obtain further 1.25 times the cut-off frequencies of the side circuits. If we regard the cut-off frequency of the side circuit in the medium-heavy loaded type as 1, we have therefore, altogether, the cut-off frequencies 1.0, 1.25, 2.0 and 2.5.

If we suppose that 2-wire circuits are employed for distances up to 600—1,000 km., we must, therefore, introduce 4-wire circuits at about 800 km. The cut-off frequencies referred to above must then be such that we can cover a distance of between 800 km., and the longest distance normally occurring. If the lowest cut-off frequency were selected at such a figure as to correspond with a range of about 800 km., almost all circuits would have to be formed of extra-light loaded lines, which are expensive. On the other hand, if the lower cut-off frequency were selected so as to correspond to a very long range, too costly lines would have to be employed for the intermediate distances. The plant and operative costs must therefore be the minimum for quite a large series of cut-off frequencies.

For what cut-off frequencies we obtain this minimum cost depends, of course, entirely upon the question of the extent to which the various lengths of circuit are used. For example, if the shorter lengths occur more frequently compared with the long distances, the cut-off frequencies must be lower than in the opposite case. In the present stage of development of long-distance telephone communication in Europe, we have little to guide us with respect to the extent to which circuits over 800 km. in length occur. It is, however, very probable that lengths up to about 1,800 to 2,000 km. occur more frequently than those of greater distances. It would therefore be politic to select the medium-heavy type of loading because it is practicable up to about these limits of distance. For this $\frac{l}{s f_1 t} = 12 - 21$, if the "building-up time" is kept at the limiting values laid down above. Fig. **11** shows in that case $f_0/f_1 = 1.45 - 1.75$ or $f_0 =$ 3,500 to 4,200. If we take the cut-off frequency $f_0 = 3{,}400$ p.p.s. for the side circuits, we have $3{,}400 \times 1.25 = 4{,}250$ p.p.s. for the phantom circuits. We would, therefore, in this case, be able easily to cover the necessary range of distance. We may therefore take the frequency 3,400 p.p.s. as the minimum cut-off frequency for both medium-heavy loaded 4-wire circuits and 2-wire circuits. Altogether we have then for 4-wire circuits, according to what has been stated above, the cut-off frequencies 3,400, 4,250, 6,800 and 8,500 p.p.s. as disposal.

(2) *Repeater Section Attenuation.* For the higher limit of attenuation between two successive 2-wire repeaters we have found (Section II.) the value $b = 1.5$. In 2-wire circuits there is generally a most favourable value for the repeater section attenuation at which reaction and echo effects are at a minimum. This most favourable value is, however, dependent upon a large number of circumstances; for example, upon the impedances of the subscribers' apparatus and lines, and upon the distribution in space of the electrical irregularities in cable circuits, so that no figure of general application can be given; it lies approximately between $b = 1.0$ and $b = 2.5$. Within this range all values of attenuation, on the average, may be regarded as electrically equivalent. Inasmuch as line costs rise as attenuation falls, we have here no reason to go appreciably below the value $b = 1.5$. In order to be sure, to some extent, of observing condition (3) we put $b = 1.4$ as the attenuation for 2-wire circuits. In 4-wire circuits the attenuation $b = 3.5$ should be regarded as the limiting value on account of the freedom from disturbance (see page 215) at the higher limits. We must here take account of the fact that in order to obtain the necessary amplifications with such an attenuation, repeaters having several stages of amplification are necessary. If the sum of the plant and operative costs of lines and repeaters is calculated, a curve is obtained for the various attenuation values, b, of the repeater section, such as shown in Fig. **12**. It will be seen in the first place how the costs fall with increasing attenuation. From $b = 3.1$ upwards an additional valve is necessary in the repeaters. We thus obtain at this point a certain increase in the total costs. It is not economical to exceed this limit. In order also to be reasonably safe we put the attenuation of 4-wire circuits at $b = 2.85$, so that finally we obtain the following general technical conditions for long distance cable circuits:—

Cut-off frequency for 2-wire circuits—
Side $f_0 = 3400$ p.p.s.
Phantom $f_0 = 4200$ p.p.s.

Cut-off frequency for 4-wire circuits—
medium-heavy—
Side $f_0 = 3400$ p.p.s.
Phantom $f_0 = 4200$ p.p.s

Cut-off frequency for 4-wire circuits—
extra-light—
Side $f_0 = 6800$ p.p.s.
Phantom $f_0 = 8500$ p.p.s.

Repeater Section attenuation:—

2-wire ... ... $b = 1.4$.
4-wire ... ... $b = 2.85$.

Transmission frequency range for all circuits:
300-2400 p.p.s.

IV.—PROPOSAL FOR THE LOADING OF TELEPHONE CABLES.

From the cut-off frequencies and repeater section attenuations all other data for telephone circuits may be calculated. If we regard, for example, the length of repeater sections, it is clear that with a given attenuation either the distances and the gauge of conductors may be made small, or long distances may be chosen and the gauge of conductors correspondingly enlarged. In the first case very many repeaters are required for a given length of circuit, and in the other case much material must be used for the conductors. For a quite definite length of repeater section there is a minimum expenditure on plant and operation. This also applies to the other data of the plant, for example, length of loading section, coil inductance, capacity of cable circuits, etc. What dimensions these data should have is a question of course to which a general answer cannot be given. The costs of construction will vary with the locality of manufacture and laying of the cable, and also with the time of year. In one country raw material is cheap and wages are high; in another country, the reverse. The cable costs largely depend upon variations in the price of raw materials. Coil and repeater costs depend, on the other hand, to a large degree upon wages; this also applies to operative costs. In the Central Laboratory of Messrs. Siemens & Halske careful calculations with respect to the most economically favourable dimensions to be given to telephone cables have been carried out on the basis of various price-ratios. With the values laid down above for cut-off frequency and repeater section attenuation, the following average figures have been obtained for lengths of repeater sections, loading sections, and gauge of conductors:—

Type of Circuit.	Gauge of Conductor. *mm.*	Length of Loading Section. *km.*	Length of Repeater Section. *km.*
4-Wire ...	0.8 — 1.0	2.0 — 2.5	90 — 110
2-Wire ...	1.2 — 14	1.5 — 2.0	100 — 110

The extent of the total costs, however, even with great deviations from these most favourable dimensions show only comparatively small variations. If, for example, the length of the repeater section is increased 50%, in which case of course all the other dimensions, corresponding to the conditions in respect of cut-off frequency and repeater section attenuation, must be changed at the same time, costs for the whole speech circuit show only a small percentage increase. This fact is important because it involves no change in regard to repeater stations already installed in most countries if the new requirements laid down above are introduced.

The calculations in accordance with which operative costs were capitalised, on the basis of 5% interest and 4.6% depreciation, showed a further appreciable difference in price between 4-wire and 2-wire circuits, and this was in favour of the latter. 2-Wire circuits, on the average, are about 25% cheaper than 4-wire circuits. This justifies the principle, laid down above, that 2-wire circuits ought to be made applicable to the longest possible distances, and brought into conformity with 4-wire circuits in respect to their electrical characteristics.

In Germany and most other countries, the average lengths of repeater section are 70 and 140 km. These distances, therefore, give with sufficient approximation the most favourable economic conditions. If they are taken as a basis, we obtain the proposal for the calculation of data for telephone cables shown in the following table here reproduced for purposes of discussion. This proposal contains the following possibilities:—

(1) In conjunction with medium-heavy loaded 4-wire circuits, circuits for compensating phase displacement can be employed. These circuits give an additional attenuation per repeater section of $b = 0.1$ to 0.15. The attenuation of the total line system between two repeaters is then $b = 2.95$ to 3.0. It lies, therefore, still within the value which can be attained without additional repeater valves. It is then, for example, possible within the range of distance determined for these circuits to increase intelligibility by reducing the " building-up times " or to extend the range of distance to all lengths which have to be dealt with.

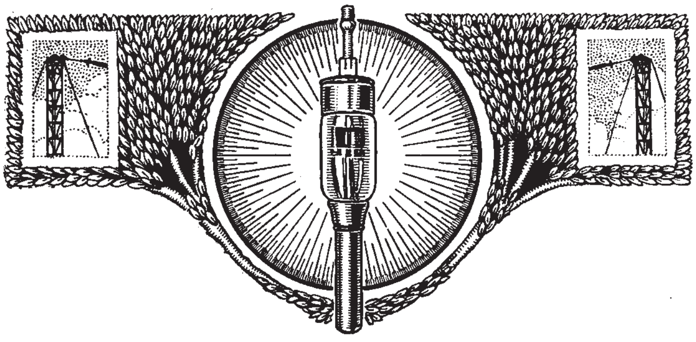
(2) 2-Wire circuits of greater length can also be equipped with phase compensation. The conditions (3) for repeater section attenuation are not affected thereby because the phase compensation circuits themselves can be freed from cross-talk. We could therefore in this case use phase compensation circuits of greater attenuation, *i.e.*, about $b = 0.2 - 0.25$.

(3) For medium-heavy loaded 4-wire and 2-wire circuits identical coil inductance and identical coil impedance are presupposed, so that for this type of circuit a single type of coil can be used.

The German Post Office Administration intends in the course of this year to load a repeater section in accordance with the proposal made, so that it will be possible by means of this to study the various questions dealt with in this paper.

PROPOSAL.

Type of Circuit.	Cut-off Frequency.	Length of Repeater Section. *km.*	Cable Constants.			Coil Constants.		Average Repeater Section Attenuation. *b.f.* = 800	Length of Loading Section. *km.*	Approximate Range. *km.*
			Gauge. *mm,*	Capacity. μF/*km.*	Leakance. μS/*km.*	Inductance. H.	Effective Resistance. *f* = 800			
4-Wire Medium-heavy Loaded.										
Side	3450	140	0.9	0.0335	0.8	0.140	6.0	2.85	1.7	1500
Phantom	4300	140	0.9	0.054	1.4	0.056	2.5	2.85	1.7	3000
4-Wire Extra-light Loaded.										
Side	7700	70	0.9	0.0335	0.8	0.030	1.5	2.8	1.7	6000
Phantom	9300	70	0.9	0.054	1.4	0.012	0.6	2.8	1.7	6000
2-Wire Medium-heavy Loaded.										
Side	3400	140	1.4	0.0355	0.8	0.140	6.0	1.4	1.7	700
Phantom	4300	140	1.4	0.0575	1.4	0.056	2.5	1.4	1.7	1100
4-Wire with phase compensation	3450	140	0.9			0.140	6.0	3.0	1.7	6000
2-Wire with phase compensation	3400	140	1.4			0.140	2.5	1.65	1.7	1100



NOTES & COMMENTS

THE following extract from "The Times" report of the general meeting of W. T. Henley's Telegraph Works, Ltd., held on the 1st July under the presidency of Sir George Sutton, M.I.E.E., Chairman of the Company, may prove of general interest:—

"TELEPHONE CABLES.

"In my reference to the expenditure on capital account, I referred to one new building for which employment might be far to seek. I had in mind a fine new building and plant we have put down to enable us to increase our output of telephone cables. We are disappointed at the small amount of work we get for these cables. We relied upon the Post Office developing rapidly the use of the telephone in this country, and it was a duty for us to provide for the demand we expected they would make upon us.

"How often have I heard abroad that as an engineering proposition there was nothing in the world to surpass the system constructed by our Post Office engineers, and yet we are so far behind other countries in developing the commercial side. What we want is that the Treasury should realise that if they cast their bread upon the waters it will return to them after many days, and not very many days at that."

Even allowing for the zeal of the canvasser in pressing the sale of his wares, we must admit there is some cause for the plaint of Sir George. One can quite understand the need for reducing the enormous annual expenditure to which the country has been committed since the war, but it is not quite so clear why the issue of capital to be used in remunerative work should be curtailed. A study of the commercial reports of the Postmaster-General for the past few years will show that in addition to paying interest on capital and on maintenance and replacement charges—which are equivalent to the dividends earned by a private company—considerable profits have been secured from the operation of the public telephone service. It is true the main underground trunk networks have practically been completed, but the traffic is rapidly overhauling the plant equipment and there are still important areas to which the benefit of a stable trunk cable service is denied. The Department is committed to considerable expenditure in connection with the conversion of the London area to automatic working—which incidentally involves the laying down of much new underground cable plant and the diversion of many junction routes—but in spite of this it is considered unwise economy to limit the issue of capital in lean commercial years, which as far as can be foreseen is almost certain to bring in a fair and ample return. Work in cable factories reacts on many other industries, and operates to the general well-being of the community.

We cannot pass from the subject matter of the above extract without thanking the Chairman for his meed of praise for the work done by the P.O. Engineering Department. A statement like this goes far towards assuaging the disgruntled feelings produced by the many cheap and flippant comments in the lay press.

PROFESSIONAL TECHNICAL COURSES AT THE PARIS TRAINING CENTRE.

M. Suchet, Engineer of the French Administration of Posts and Telegraphs, describes in " Annales des Postes Telegraphes et Telephones," of July, pp. 597-611, the technical courses given at Les Ateliers du Boulevarde Brune, Paris, to the various grades of officials. The classes cover Line Construction in all its varied branches, and maintenance of all kinds of telegraph and telephone apparatus, including automatic telephones. Practical instruction is given to pupils of the " Ecole superieure " as well as to Junior mechanics and linemen. The professors and instructors number 35 and deal with some 500 pupils a year. A detailed description of each course with photographs of the pupils at work is given.

TESTS OF THE BAUDOT-VERDAN RADIO APPARATUS.

A description of this very ingenious adaptation of the Baudot telegraph system for dealing with Radio work when atmospherics are causing difficulties was given in " Annales des Postes Telegraphes et Telephones," in 1925, p. 645. There is now published in the same journal in the July issue of this year, pp. 562-581, a detailed description of tests made between Paris and Tananarivo, Madagascar, in September, 1926, with a Baudot Triple set. A short description with diagrams of the arrangements used is given as well as photographs of the printed signals which were recorded on the Baudot apparatus. Messages were received when Morse working was totally interrupted due to a thunderstorm near the receiving station. A comparison is then made of the advantages of the 5-unit code over the Morse, and the Telautograph methods for Radio work. A concluding note emphasises the facility with which " Unison " between the two Distributors at Paris and Tananarivo was maintained.

ROTTERDAM MUNICIPAL TELEPHONE SERVICE.

In the January, 1927, number of this Journal some data were quoted from the Annual Report for 1925 of the Rotterdam Municipal Telephone Service. The Annual Report for 1926 has now been received and it may be of interest to consider the progress of the system during the past year.

The total number of lines on the 31st December, 1926, was 19,752—an increase of 949 during the year. Of the three exchanges, Botersloot, with 12,552 subscribers, is still manual, but Vlaggemansstraat, with 2,916 subscribers, is now completely automatic, while of the 4,284 subscribers on Thorenaarstraat, 2,389 are full automatic. It is expected that the conversion of Botersloot to full automatic working will take place during 1928.

The automatic plant continues to fulfil expectations, and again it is recorded that no serious fault has occurred.

Local traffic increased during the year by 9%, but, on the other hand, traffic with other cities diminished by 3.5%.

From our point of view, the large increase of traffic from England—from 42,195 to 57,544 calls is very gratifying. As would be expected, however, the bulk of the foreign traffic is with Germany (280,940 calls) and Belgium (125,115 calls). France is a bad fourth with 3,963 calls.

Subscribers' complaints averaged 3.32 per subscriber per year, as against 3.40 in 1925 and 3.60 in 1924. Actual faults, however, were only 2.33, as against 2.36 in 1925 and 2.54 in 1924.

The profit on the year's working amounted to nearly 918,000 florins.

Mr. R. A. Dalzell, C.B., C.B.E., Director of Telegraph and Telephone Services, has retired after forty-seven very active years of service. He was the first occupant of the post of Director and he has set a very high standard for his successors to follow. In the N.T. Company's administration the district manager was also the engineer—or should we not rather say the engineer was also district manager? In both these capacities Mr Dalzell secured valuable experience and displayed conspicuous energy and ability, and from 1905 until the Company was taken over he was Provincial Superintendent of the Western Province. The administration in the G.P.O. North speedily recognised the practical value of Mr. Dalzell's wide knowledge of the requirements of the service, from the administrative, engineering, and even the subscribers' view points, and it was only fitting that when the demand arose in 1922 for a commercial manager for the telegraphs and telephones the Postmaster-General should turn to his Chief Inspector of Traffic, who possessed the necessary qualifications for the post. Although sixty-two years old, Mr. Dalzell is full of vigour and he retires with the best wishes of everyone he came into contact with for a long spell of good health and happiness.

John Lee has also gone. His career is dealt with elsewhere in this Journal. A charming personality, debonair and witty, with a wide and sympathetic knowledge of men and things, he achieved wonderful results in the C.T.O., which used to be a notoriously difficult place to handle, and his successor, Mr. J Stuart Jones, will find the way much smoother than it otherwise would have been had not an administrator like John Lee first occupied the controller's chair. We offer now our best thanks to Mr. Lee for the many courtesies and services he so willingly rendered to us, and a message of congratulation to his successor.

The following letter from Colonel Clay is interesting to our present day telephone engineers. It gives a good instance of the initiative and resource of the old-time Company's men. We leave it to our readers to find the name of the manager who was so conveniently lost for a time.

Hurst,
Sundridge Avenue,
Bromley, Kent.
25th July, 1927.

THE EDITOR, *Post Office Electrical Engineers' Journal.*

Dear Sir,

In your Journal for April Mr. Shea shows several interesting ancient line structures. A few notes on the Sunderland one may be of interest. I do not remember the cost or by whom it was built, but the circumstances were that the Company were restricted to a wooden structure. There was no chance of staying otherwise than on the one house. The previous structure was on similar lines but not properly braced, and although it had only been erected five or six years it was unsafe.

To *get leave* to erect a new structure was hopeless. This new one was erected in the road where it was made; every piece numbered and taken down. Then the manager went away and left no address. His deputy, Mr. G. F. Preston, was requested to get the old structure down and the new one erected in the shortest possible time and not to let anything stop the work. This he certainly did.

The owner's solicitor was soon at the office asking for the manager, who, however, could not be found. The solicitor said the work must be stopped. Mr. Preston had other views; it was not safe to do so. The work was completed by the time the manager returned, or perhaps it would be more correct to say the manager returned when the work was completed and had a very hot time. He will never forget the interview with the owner's solicitor, but, as your illustration shows, the structure remained sound to the end.

It was designed by a local architect under instructions from Mr. Preston and myself. The fact that it did its work for forty years and was only removed because it was no longer required shows, as Mr. Shea says, " It was built like a rock."

Yours truly,
C. B. CLAY, Lt.-Col

THE LATE MR. W. H. WINNY.

The following description of the funeral of the late Mr. W. H. Winny is taken from the " Daily Telegraph " of the 6th June:—

The funeral of Mr. W. Humphris Winny, O.B.E., Knight of Grace, late Commissioner of the No 1 (Prince of Wales) District of the St. John Ambulance Brigade, took place on Saturday at the City of London Cemetery, Ilford. The first part of the service was held at St. Paul's, Camden Square, N.W.

In addition to the members of the family and a large number of the No. 1 District, the congregation included Major-General Sir Percival Wilkinson, representing the Order; Chief Superintendent R. J. Halford, representing the City Police; Mr. Dundas Grant, representing the G.P.O.; Colonel Moore, representing the Chief Commissioner of the St. John Ambulance Brigade; Major Darvil-Smith, representing the Brigade Headquarters; and Sir Dundas Grant, a great personal friend. A guard of honour was formed by the members of the No. 1 District. The new Commissioner, Lieut.-Colonel F. A. Brooks, who read the Lesson; his Assistant Commissioners, Dr. MacFadden, Dr. N. Corbet Fletcher, Dr. G. W. Kendall, the District Surgeon, Dr. R. Connon Robertson, and his District Staff acted as pall-bearers. District Officer S. J. Warren carried the late chief's decorations on a cushion.

In addition to the family wreaths there were wreaths from No. 1 District, from the Venerable Order, from Mrs. Lancelot Dent, Lady Superintendent of Brigade Overseas, from his colleagues in the Post Office Engineering Department, from Sir James Dundas Grant, and many others.

Mr. Winny was a fine chemist and was for several years in charge of the testing laboratory at Mount Pleasant. He became an Assistant Staff Engineer by examination and was attached to the Test Section. For many years he was on the teaching staff of the Northampton Polytechnic Institute. He rendered very valuable services during the air raids on London during the war and was awarded the order of Officer of the British Empire for his work with the St. John Ambulance organisation.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Wakefield	New Auto.	945
Sandal	,,	250
Llandudno	,,	1140
Colwyn Bay	,,	1220
Sheffield Central	,,	6300
Beauchief	,,	800
Owlerton	,,	800
Sharrow	,,	1500
Broughty Ferry	Auto. Extn.	275
Dundee	,,	915
Ecclesfield	,,	90
Torquay	,,	300
Govan	New. Manual	660
Walton-on-Thames	,,	1040
Doncaster	Manual Extn.	340
Rusholme	,,	460
Wimbledon	,,	1820
Birmingham Test Deck	,,	—
Bradford	,,	560
Reigate	,,	800
Worcester	,,	720
Buckhurst	,,	480
Cambridge	,,	420
Harrow	,,	1530
Bristol Corporation	P.A.B.X.	90
Lipton Ltd.	,,	100
Asquith Ltd.	,,	30
Dunlop Rubber Co.	,,	80
Middlesbro Co-op. Society	,,	50
Plymouth Corporation	,,	210
Shell Mex Ltd., Strand	P.A.B.X. Extn.	40
Butler & Co.	P.A.B.X.	30
Accles & Pollock	,,	50
Liverpool Warehousing	,,	60
Royal Berks Hospital	,,	50
W. Goodyear & Sons	,,	30
E. S. & A. Robinson	P.A.B.X. Extn.	—

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
Archway	Auto.	3200
Southend	,,	3040
Gt. Wakering	,,	300
Hadleigh	,,	420
Leigh-on-Sea	,,	1950
Marine	,,	1430
Rochford	,,	175
Thorpe Bay	,,	760
Hillside Park	,,	2400
Reliance	,,	2700
Croydon M.F.	,,	—
Maida Vale	,,	7500
Cowley	,,	200
Headington	,,	200
Summertown	,,	600
Haxby	,,	85
Temple Bar	,,	7900
Langham	,,	8050
Dringhouses	,,	180
Liverpool Observation Desk	Manual.	—
Upminster	,,	440
Chigwell	,,	520
Ambassador	,,	2000
African & Eastern Corporation	P.A.B.X.	60
Barrow Corporation	,,	40
Brinton & Sons	,,	40
Waring & Gillow	,,	170
Meccano Ltd.	,,	50
British Electrical Federation	,,	80
Steel Nut & Hampton	,,	30
Pendleton Co.-op. Society	,,	30
Shell Mex Ltd., Weaste	,,	20
Reading Co-op. Society	,,	20
Electra House Ltd.	,,	230
Shell Mex Ltd., Aberdeen	,,	20
Midland Bank, Piccadilly	,,	40
Nelson Co.-op. Society	,,	6
Ocean Coal Co.	,,	10
Shropshire Power Co.	,,	40
Wood Green Council	,,	40

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
York	Auto.	465
Giffnock	Manual.	800
Belfast Relief	"	—
Berkhamsted	"	580
Cambuslang	Manual	280
Bristol Relief	"	1700
Sale	"	420
Salisbury	"	460
Windsor	"	300
E.S. & A. Robinson	P.A.B.X.	—
Daily News	"	30

LONDON DISTRICT NOTES.

During the quarter ended 30th June, 1927, the nett increases in the number of Exchange Lines, Extensions, and Stations respectively were—4993, 5220 and 8414.

Mileage Statistics.

The following changes have occurred during the June quarter:—

Telegraphs.—A nett decrease in open wire of 4 miles and a nett increase in underground of 84 miles.

Telephones (*Exchange*).—A nett decrease of open wire (including Aerial Cable) of 23 miles, and a nett increase in underground of 72,892 miles.

Telephones (*Trunk*).—A nett increase in open wire of 42 miles, and in underground of 309 miles.

Pole Line.—A nett increase of 63 miles, the total to date being 5,728 miles.

Pipe Line.—A nett increase of 333 miles, the total to date being 8,887 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,689
Telephones (Exchanges) ...	2,062,444
Telephones (Trunk) ...	66,658
Spares	129,849

Internal Construction.

The Extension at Reigate Exchange, which was commenced on 13th April, was completed on the 30th July and proposals are now in hand to instal a new suite of Boards (22 positions) to extend to the full capacity of 2,780.

An extension at Harrow Exchange by 1,100 locals plus 3,000 Multiple has been completed and brought into use on August 10th.

Work is proceeding on the Automatic Exchanges at Holborn, Bishopsgate, Sloane, Western, Bermondsey and Monument. The former is practically completed and hopes are entertained of this Exchange being ready in October or November.

New Exchanges for Barnes (to be named Prospect), Merstham and Hatch End are in course of installation.

General.

Tandem Exchange.—On August 18th there occurred what must be regarded as one of the most outstanding events in the history of the Telephone. This event was the opening for public service of the new Tandem Exchange. Widespread interest has been aroused in connection with this exchange. A full description appears elsewhere in this issue.

During the two months preceding the opening the apparatus was subjected to the most rigorous tests; over one million calls were passed under "artificial traffic" conditions; routine testing was also carried out daily at all exchanges.

On the opening day the utmost interest was displayed by all concerned and the results watched with great care by Engineers and Traffic Officers alike. The opening of Tandem is the preliminary step to the conversion of the London area to automatic conditions and if the subsequent changes from the manual to the automatic system are equally satisfactory there is no doubt that the capital of the Empire will be provided with a telephone system which will rank second to none.

MR. THOMAS PLUMMER, M.I.E.E.

MR T. PLUMMER.

By the retirement of Thomas Plummer, or "T.P." as his intimates preferred to call him, at the end of July, the Engineering Department has lost an outstanding personality and one who was devoted to it. His association with the Post Office may be said to have commenced at birth, his mother having been a Head Postmistress.

Born at New Ross, Co. Wexford, he was educated at Pocock College, Kilkenny, where he gained a scholarship tenable for three years, followed by another for one year at Santry School, Co. Dublin. He early developed a leaning towards science and obtained certificates in the advanced stage of Physics and Mathematics.

After a short period on the Postal side he entered the Engineering Department at Cork in August, 1885, as a Junior Clerk in the office of Mr. H. Pomeroy, then Superintending Engineer of the Southern Ireland District. As there were only three clerks in the office the training was of an all-round character. His interest in technical telegraphy was aroused, and in 1886 he was awarded the City and Guilds Bronze Medal and £5 prize in the Honours Stage of Telegraphy. At a later date, when Telephony had become a separate subject, he added to his previous success the Silver Medal and £5 prize with First Class Honours in that subject; he also took similar honours in Electric Lighting and Power and Electro-Metallurgy.

His promotion to a Second-Class Engineership came in 1893, and three years later he was selected by the Engineer-in-Chief to assist in the transfer of the Trunk Telephone Service from the late N.T. Company to the Post Office. He was so engaged at Sheffield, Glasgow and Blackburn; and for a time was attached to the old N.W. District at Manchester to supervise the fitting of new Trunk equipment in most of the towns in that District.

Promoted to a First Class Engineership in 1897, he served under the late Mr. M. Cooper in the Telephone Section at Headquarters, where he took an active part in the development of the Post Office telephone service in London and the Provinces. Further promotion to Second Class Technical Officer came in 1900, and a few years later (1906) in accordance with the policy at that time which required Headquarters officers to obtain provincial experience, his activities were transferred to Liverpool as Assistant to Sir William Slingo, Superintending Engineer of the N. Wales District, whom he eventually succeeded in 1911.

A rearrangement of Districts led to Shrewsbury becoming the headquarters of the District. Liverpool and its environs passed to the S. Lancs. District, and North Wales absorbed a portion of the old S. Midland District, including Birmingham, the Black Country and The Potteries.

His long association with the N. Wales District gave him an intimate knowledge of its staff and affairs which was not surpassed, and which impressed all who had occasion to discuss them with him.

His membership of the Superintending Engineers Advisory Committee since 1913 entailed a detailed knowledge of many and diverse details of everyday work, and his close application to these was at once an inspiration and an example. In the midst of his many activities he was never too busy to examine any matter placed before him.

As Chairman of the N. Wales Branch of the

I.P.O.E.E. his active personal interest was largely responsible for the well-attended meetings and the high percentage of its membership. He was rarely absent from a meeting, took a leading part in the discussions and himself contributed many interesting papers.

His membership of the I.E.E. extended over thirty years, and he served on the Committee of the Birmingham Local Centre, acted as Vice-Chairman and was prevented from accepting the Chairmanship only by residence in Shrewsbury.

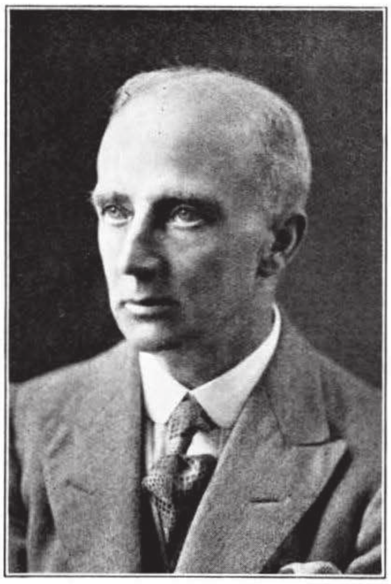
In spite of these pre-occupations he had numerous outside interests, being on the Committee of the Shropshire Philosophical Society and also its Chairman for a session. The local Radio Society also claimed his attention and services as Chairman.

Rowing and " Rugger " were his relaxations in earlier years, and they typify the vigour of his later years. To the day of retirement he was an active cyclist, undeterred by any weather.

The leisure which retirement affords will doubtless enable him to enjoy fully his membership of the Caradoc Field Club, which caters for the geologist, the botanist and the archæologist in the beautiful country around Shrewsbury where he will continue to reside. His many friends hope that these pursuits may enable him to regain the sound physical health which he had enjoyed until recently.

B. J. GILL.

EDWIN JOHN ELDRIDGE, M.I.E.E.



MR. E. J. ELDRIDGE.

MR. E. J. ELDRIDGE, Superintending Engineer of the South Western District, retired on the 30th September, 1927, after completing 40 years' service.

Mr. Eldridge commenced his career in July, 1881, as a telegraphist in the Central Telegraph Office, where he remained 4 years, passing thence to the Registry Branch of the Secretary's Office, and, subsequently, in 1887 became a Junior Clerk in the Engineering Department. From this time onwards he rose successively through the ranks of Engineer, Technical Officer, Asst. Superintending Engineer to Staff Engineer, and in 1911 he became Superintending Engineer of the North Midland District. In 1915 he went to the South Western District headquarters at Bristol, where he remained until the date of his retirement.

About 1893, when relieving the engineer of the Western District of London, Mr. Eldridge was associated with an American engineer in carrying out experiments with the " Telautograph " between the Engineer-in-Chief's Office and the W.D.O. Four wires were then in use for the purpose, but reasonably satisfactory results were obtained only as long as an expert was in attendance.

One instance of the difference between the past and present day methods is exemplified by the following narrative, which Mr. Eldridge relates with much interest. As a 2nd Class Engineer he was deputed to overhaul the Metropolitan Police System (then an A.B.C. installation). At Woodford Police Station he found that repairs to the keys of the transmitters had been carried out in a very crude manner and he asked for the name of the lineman who had done the work. The Inspector in charge of the station replied:—" We never trouble the lineman. If anything goes wrong we get the potman from the Pub. over the road to come across and put things right! "

He undertook, among many other special duties while in the London District, the first change-over in TS. from primary to secondary cell working, and in Oct., 1898, in association with the late Mr. J. Leyshon (affectionately known as " Uncle " by all who knew him), was employed under the late Sir (then Mr.) John Gavey in making what was then described as a telephone survey of London, together with the preparation of estimates, paving schedules, reports, etc, for the Secretary. During the progress of the works were authorised subsequent to the survey, difficulties arose in the supply of stores in sufficient quantity to carry out the work expeditiously, and Mr. Eldridge was appointed by Mr Gavey to act with the late Mr. W. H. Allen—representing the Controller of Stores—to determine the orders to be placed, the rates of delivery, etc.

In June, 1905, he was called upon by Mr. J. Gavey to prepare for him, in readiness for the evidence he was to give before the House of Commons Committee, an estimate of the valuation of the National Telephone Company's plant which was to be acquired by the Department in 1912. Ducts, cables, switchboards, subs. apparatus, open wires and buildings were to be valued separately, and as only a week was available for the purpose, neither Mr. Eldridge nor Mr. A. E. Chandler, who assisted him, found the time hanging on their hands!

The amount arrived at was £13,270,125.

Some 7 years later, after a very detailed valuation, the Arbitrators assessed the replacement value at £13,059,827, with a depreciated value of £12,515,264. Each set of figures excluded the Private Wire business of the Company, which was dealt with independently. Such a close approximation as that arrived at by Mr. Eldridge was undoubtedly a very satisfactory forecast, and must have been of great assistance to the then Engineer-in-Chief during the detailed investigations carried out prior to the arbitration proceedings.

After spending 4 years as Asst. Superintending Engineer in the North Metropolitan District, Mr. Eldridge returned to Headquarters in April, 1909, as Staff Engineer. During his stay at Headquarters he was for some weeks, consequent on the illness of the Superintending Engineer, Mr. E. Catley, in charge of both the North Metropolitan District and the Headquarter Construction Section, spending the forenoon in the former and the afternoon at Headquarters.

In January, 1911, Mr. Eldridge was appointed Superintending Engineer and from this date until the date of his retirement he remained in the Provinces.

During the War Mr. Eldridge's unflagging activity found wide scope owing to the heavy demands of naval and military requirements in the District.

In addition, in 1916 he was connected with the hurried provision of the Repeater Station at Penzance. The Imperial Cable connecting Halifax, Nova Scotia, with Penzance and London was formed by means of an ex-German Atlantic cable, and within six weeks of the necessity for the Repeater Station at Penzance becoming known the Office had been established, and the underground cable connecting Penzance with Mousehole—a distance of 3½ miles—completed, the latter being the landing place of the submarine cable. The Repeater Station premises (then a billiard room) were required under D.O.R.A., were adapted and equipped and a fisherman's unroofed shed or tank was made suitable for a Cable Hut, and utilised accordingly.

The interests and activities of Mr. Eldridge was not confined to service organisations. Outside the Service he is well known and held in high esteem, and among his varied interests outside official life are the following:—

Fellow of the Royal Colonial Institute and Member of Council, Bristol Branch.
Member of Committee of Institute of Electrical Engineers (Western Area).
President of both West of England (Civil Service) Bowling Association and Bowling Club.

He is fond of gardening and has recently taken to golf, and with his usual cheery optimism is looking forward to reaching championship form in the near future.

Time has dealt kindly with him and he retires full of vigour and in good health. His retirement was a matter of regret to all who served under him, and it is the wish of his many friends both inside and outside the Service that he may live many years to enjoy his freedom from official cares.

A.E.C.

JOHN LEE.

JOHN LEE entered the Liverpool Post Office in 1883. His first appointment was on the Telegraph side, but he became associated with the working of the trunk telephone lines at Liverpool on their acquisition by the State in 1896. In his new work he lost no opportunity of personal discussion with subscribers, and in this way he acquired an insight into the public attitude not only towards the new service but also to Government control in general This was of particular value to a man who, as time went on, developed an ever-increasing interest in the problems of Public Administration.

In 1906, Lee became Chief Clerk at the Birkenhead Post Office, but this was regarded generally as a provisional appointment and his promotion in the following year to one of the new Assistant Traffic Managerships at Headquarters created no surprise. The new work afforded great scope to a man of Lee's ability. The trunk telephone system had from the first grown very rapidly, but the opening of Local Exchanges by the Post Office in London and elsewhere as the result of the recommendations of the House of Commons Committee of 1898 gave it a remarkable impetus. Little research work on the traffic aspects of long distance working could, however, be carried out until an expert body had been created at Headquarters to co-ordinate the studies which were being made in the Trunk Exchanges up and down the country.

In 1909, John Lee was sent to India to advise on the working of the Railway Telegraph System, and in 1911 he went to the United States, in company with Colonel Purves, Luart Jones and the late A. W. Martin, to study and report on the working of the American telephone system.

In September, 1911, he became Telegraph Traffic Manager, in April, 1916, Deputy Chief Inspector of the reorganised Telegraph and Telephone Traffic Section at Headquarters, in 1917, Postmaster of Belfast and finally, in 1919, Controller of the Central Telegraph Office in London.

Of special tasks, John Lee had his full share. Some have already been mentioned. In 1917, he was largely responsible for the arrangements for the employment of women telegraphists and telephonists on the lines of communication in France, in 1920 he attended the Paris Conference in connection with the restoration of European communications, and in 1925 he was appointed Head of the British Delegation to the International Telegraph Conference at Paris. His task at the latter was particularly exacting, as he was nominated as President of the important Réglement Committee. The Conference had not met for 17 years and after war economic conditions had created problems the solution of which needed more than ordinary ability. John Lee carried out his task with striking success. There was no more popular man at the Conference and at the termination of the work of his Committee he was given a reception which no one present will easily forget.

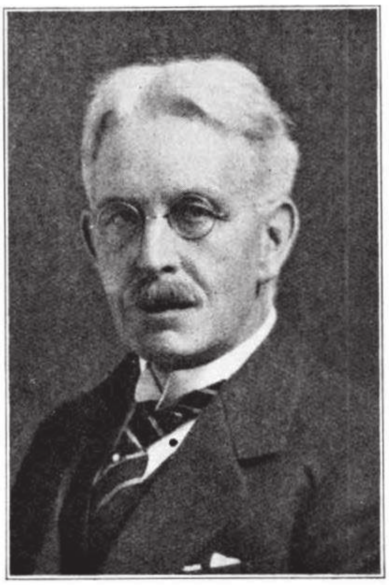
As an office chief John Lee has had few equals in the Post Office. He has a genius for leadership. No one has tried more earnestly to make Whitleyism a success. It has always been his endeavour to carry his staff with him even in minor changes. He is not one of the "strong silent" men about whom many people cherish romantic illusions. He positively revels in discussion. His first move when anything special was in hand was, not to bar himself in his room and indulge in hard thinking, but to get together all those concerned and start a sort of communal thinking aloud. Presided over by a man with Lee's wealth of ideas and extraordinary quickness of perception, such meetings could be remarkably effective, as those who served under him at Paris in 1925 can testify. He did not lose sight of the educational value of committee work to the more junior men, whom he frequently appointed to serve on the committees he set up in his own office.

John Lee has always had many interests outside the official world. He is a keen Churchman and a lecturer and writer on many subjects. A man with the widest sympathies, he has interested himself extensively in Industrial Welfare and has acted as Chairman of several conferences on the subject.

Shortly before his retirement, Lee became seriously unwell, but the latest news of his health is reassuring and there is every reason to hope that he will be able to continue some at any rate of his activities of the past, in addition to his new responsibility as a Director of the Automatic Telephone Company and its associated concerns.

H.G.T.

G. F. MANSBRIDGE.



MR. G. F. MANSBRIDGE.

THE following bald statement of facts extracted from "Who's Who in Engineering" gives a record of the career of one who, although never actually in the Engineering Department, is endowed to his finger tips with the instinct and spirit of the engineer and is perhaps one of the best known P.O. men in engineering circles outside the service:—

George Frederick Mansbridge, O.B.E., M.I.E.E., M.Soc.C.E. (France): Vice Controller, Stores Department, G.P.O. since 1924; born 1867; educated at the Haberdashers Schools; some time assistant to Prof. Daniell; assistant to Sir Wm. Slingo, science school, C.T.O.; in charge Test, C.T.O. Land lines 1887-91 and Submarine Cables 1892-4; Chief of Testing Department (Materials) 1895-1902; Assistant Supt. and Supt. Telegraph Factories 1903-13; Assistant Controller, P.O. Stores Department 1914-24; Principal of Electrical Engineering Department, Croydon Polytechnic 1897-1916; Triple Medallist Electro-Technology; Patentee Static Condensers, Inductance Standards, Cables, etc.; Consulting Engineer to Mansbridge Condenser Co. Ltd.

It is perhaps in connection with the invention of the paper foil condenser that Mr. Mansbridge's name is usually associated, but that far-reaching innovation was only one episode in a very busy official life. The Mansbridge condenser was brought into the world a little too soon from one point of view since the patent rights had expired before the popular arrival of broadcasting, which opened an enormous field for the use of condensers. Nevertheless, the new process of manufacture was adopted quickly throughout the world under the fostering care of the earliest licencees—The Western Electric Coy. and the British Insulated and Helsby Co.—and prices for paper condensers came tumbling down to about a quarter of their previous figures. Another piece of apparatus, now widely used as a tuner in radio sets, especially in America, and called erroneously a variometer, was introduced first by Mr. Mansbridge in his "Variable standard of Self-Induction," and here again his product was ready before the big market had developed.

One portion of his work Mr. Mansbridge looks back upon with a justified degree of satisfaction—for the whole business was a labour of love with him—was in connection with the vocational and general education of working lads. It may be of interest to mention that the work done at the P.O. factories stimulated the educational authorities to embark on similar schemes, and that the Holloway Factory workshop allocated for this purpose was reproduced by the L.C.C. in their advertising posters as an illustration of what could be and was being done, though of course without disclosing the origin.

Mr. Mansbridge is so much younger than his years, busy years though they were, that he cannot now sit down quietly and take his ease.

He is, we understand, joining the board of the Phœnix Telephone and Electric Works Ltd.

On the 1st September he was presented with a silver cigar cabinet and a silver rose bowl for Mrs. Mansbridge by his colleagues in the Stores and other departments. The presentation was made by Mr. Sparks, Controller, before a large gathering at Bedford Street. Congratulatory and reminiscent speeches were delivered by representative men from the Stores and Factories, and Mr. S. A. Pollock testified to the esteem in which he was held by the Engineering Department. A letter of regret from Col. Purves for his unavoidable absence was read. Mr. Mansbridge made a characteristic reply, and Mrs. Mansbridge in a short charming speech said she was glad in one sense that her husband had retired as she was confident and hopeful she would now have him longer at home than he had been during his official career.

LOCAL CENTRE NOTES.

[*The following notes were received too late for inclusion in the July issue.*—EDS., *P.O.E.E.J.*]

SOUTH MIDLAND CENTRE.

On the 23rd February, 1927, Major E. C. Harris read his paper on "The Training of Inspectors," and dwelt upon the numerous qualifications and essentials of a good Inspector.

In opening the discussion Mr. Roach mentioned the courage required to read such a paper. It seemed to him, however, to be largely advice to aspirants and to set forth ideals. He agreed with what had been said, but would prefer to take the Secretarial files as a standard for reports rather than Macaulay as advocated by Major Harris. Mr. Roach regarded the particular weakness of Inspectors to be in their dealing with Wayleaves; he suggested preparedness as an essential and mentioned the importance of prompt transport.

Mr. Gilpin enquired regarding Advice Notes and the limit of £100 and also the division between "C.S." work and development.

Mr. Bolton asked whether the proposals were actual requirements or were just pious aspirations. Mr. Cook's remarks were mostly criticism. He failed to see any particular method of training in the paper, but regarded it rather as notes for would-be Inspectors. The present system put the onus on the man who adopted a "trial and error" method and he was often left without guidance. The Inspector's job was a difficult one, it embraced a great variety of subjects and required agility of mind. He recommended the study of mathematics as a very suitable means of mind training. He also enquired as to the means of edifying the skilled workmen whom he divided into two types—those who sought advancement and those who would not be bothered. He advocated a course for selected workmen similar to that now given to probationary Inspectors and also the holding of round table conferences to which difficulties could be discussed and advice given.

Mr. Lewis was anxious with regard to the treatment of new entrants. He regarded the present "Youth-in-Training" system as unsound, inasmuch as educated youths were employed haphazardly for some time and there was a danger of the benefit of their academic education being lost. They were not being trained at present and he advocated a system similar to that adopted in the Admiralty Dockyards where during the first four years of their service the apprentices were employed half time on practical work and half on theoretical training. The system, he contended, had produced many Whitworth Scholars.

Mr. Gravill congratulated the lecturer, but regarded the paper as a statement of the duties of an Inspector and of his qualifications before appointment. The question of how they were to be trained was still unanswered and he suggested attaching them to a skilled officer for six weeks where they would have easy access to the regulations, deal with the correspondence and see the execution of works. He was also disappointed with the present system of training youths and emphasised the importance of tuition on internal work, the care of motor vehicles, the systems of loose-leaf diagrams, cable records, and Inspectors' duties generally. Mr. T. Martin also congratulated the speaker and enquired as to the avenues for the advancement of

Draughtsmen to the Inspectors' class. He considered that experience as Draughtsmen made them very suitable for development work. Mr. Pendry enquired regarding the use of Technical Instructions and forms and also of credit for Engineering work. He hoped for a paper on these lines.

Major Harris suitably replied to the speakers and the meeting concluded with a vote of thanks to him.

At the meeting held on the 30th March the Chairman presented a cheque and a certificate to Mr. F. V. Padgham of Guildford, awarded for his essay. "Transmission Testing Sets," and a certificate of merit to Mr. N. V. Knight for an essay entitled, "Automatic Exchanges—Non-Director Areas." In congratulating the winners, the Chairman expressed his pleasure that the prestige of the South Midland District had been maintained in the 1926-27 competition.

Mr. S. Moody read a paper "Advice Notes."

The steps which it was necessary to take immediately after an A.N. is received were stated and Mr. Moody made suggestions which, it was claimed, would shorten the period between the enquiry for telephone service and (if an agreement is signed the receipt by the Inspector of instructions to proceed. An amendment to the W.I. forms was also proposed.

The author was of the opinion that unnecessary records were sometimes kept in local offices.

The question of making a survey in the case of smaller works was investigated at some length and definite suggestions were made in this connection and a new type of survey form proposed.

Mr. Moody ended with a promise that the execution of the work would form the subject of another paper.

Messrs. Dwyer, Wakefield, Mullens, Gilpin, Beaumont, Halton and H. W. Peck took part in the very interesting discussion and the Chairman thanked the author for his efforts.

The latter part of the meeting was devoted to a paper: "Advice Note work from an Engineering point of view," given by Mr. W. L. Taylor.

After describing an A.N., the necessity for promptitude in carrying out the work was stressed, particular attention being given to the negotiation of wayleaves, adequacy of staff and supply of stores.

Mr. Taylor passed on to demonstrate the importance of preventing annoyance to a Subscriber by giving close attention to details of the work required for his connection. A plea that development schemes should be extended to overhead plant and not confined to proposals for underground conductors was put in and the author did not agree that the work of preparing development studies should be transferred from the District Managers to the Engineering Department.

Proposals to convert the Ford vans into carriers of light poles and also alteration of a method of leading-in were explained.

Points to be watched when running internal wires were set out and the paper ended with three maxims.

Various items for discussion were initiated by Messrs. Halton, Dwyer, Capt. Linsell, Messrs. Beaumont, Bolton and the Vice-Chairman, and the last mentioned thanked Mr. W. L. Taylor in the name of the audience.

At the final meeting of the 1926-27 Session, which took place on the 27th April, Mr. P. J. Campbell lectured on "Power Plant, Acceptance Testing." The paper covered the tests applied to apparatus, machines, oil engines, and secondary cells installed in telephone exchanges.

The voltmeters, ammeters, watt-hour meters, circuit breakers and motor starters were in turn described and the precautions which should be taken in using those instruments were given in some detail.

D.C. charging motor generators were then defined and the standard tests explained, the influence of temperature being specially examined.

Two types of ringing machines and direct coupled oil engines and generators next received attention and the paper ended with useful practical details about secondary cell installations.

The 21 slides were of great assistance to the audience in following a lecture which covered so many different types of apparatus.

In the discussion Messrs. Atkins, W. L. Taylor, Capt. Linsell, Messrs. Wakefield, Lines, Major Harris and the Vice-Chairman took part and many requests were made for copies of the paper to be circulated. The Vice-Chairman, in the absence of the Chairman, who had to leave before the close of the meeting, promised that members would see a copy of the paper and, amid applause, heartily thanked Mr. Campbell.

A.W.L.

NORTH WALES CENTRE.

The sixth and final meeting of the Session was held at Shrewsbury on 23rd March, 1927, when Mr. H. W. Green read a paper entitled, " The protection of the Department's overhead plant against contact with power circuits."

The lecturer first rehearsed the various powers under which tramways and light railways are erected and described the procedure adopted during the passage of Tramway Bills in Parliament to ensure that the Postmaster-General's rights are safeguarded. He then proceeded to describe the guarding arrangements required by the Ministry of Trasnport regulations and to exhibit slides showing diagrams of the guard wires required for various weights of conductors and spacings of wires. The use of insulated wires for crossings over low pressure systems was also covered. The audience numbered 80 and a good discussion followed the reading of the paper.

The membership of this centre is 165, or 91% of the eligible staff, and the atendances at last Session's meetings have been between 75 and 100. The local committee is this year in the fortunate position of having a full programme of lectures already offered for next Session.

J.G.K.D.

BOOK REVIEWS.

" Questions and Solutions in Telegraphy and Telephony."

By some mischance the name of the publisher of " Questions and Solutions," by H. P. Few, was omitted from the review in the July number of the Journal.

The publishers are S. Rentell & Co., 37c, Maiden Lane, W.C.2. Copies can also be obtained direct from Mrs. Few, 110 Sussex Road, West Harrow, Middx.

" Automatic Telephony." By Charles W. Wilman, A.M.I.E.E. (Lecturer in Telephony at the Coventry Muncipal Technical Institute). Crosby Lockwood & Son. 7/6 net.

This book should prove very useful to those already experienced in the practice of Automatic Telephony, also particularly to beginners and students on account of the author's careful enunciation of basic principles. The earlier chapters deal, amongst other useful matter, with Relays and their time elements, types of Switches, and Subscribers' Equipment, the latter including a very good description of the Dial mechanism. Preselectors, Group and Final Selectors are carefully described and their relevant functions and Circuit Diagrams explained in detail. The detached contact diagram method is used and the explanations are extremely lucid and easy to follow. Two very readable and informative chapters are devoted to Trunking principles and another to Exchange Equipment and Wiring. Others describe shortly Private Automatic Exchanges, and Private Automatic Branch Exchanges, Party Line working and other miscellaneous and auxiliary arrangements.

Later chapters deal with multi-office areas and the London Director system, with a brief description of the Controller system. In addition to the foregoing, much useful information in respect of the application of general principles to modern practice is given. The size of the volume restricts the amount of detail possible, but very effective descriptions are achieved. The book is well printed, containing 223 pages and 76 diagrams and is a useful addition to the literature of Automatic Telephony.

W.D.S.

" The Elements of Telephone Transmission." By H. H. Harrison, M.I.E.E., M.I.R.S.E. Longmans, Green & Co., Ltd. 147 pp., 72 diagrams. 5/- net.

This book is intended as an introduction to the subject and has been written for the use of elementary students. The division of the book into four chapters facilitates logical treatment of the subject. The physical and the general mathematical aspects of transmission have been dealt with. The preliminary mathematics leaves something to be desired and in this respect fulfilment of the avowed objects of the book has not been achieved.

Chapter I. is exclusively mathematical and as far as its scope or range is concerned it meets the requirements of the succeeding chapters. In regard to the actual presentation, there is considerable looseness of expression and at times, and apart from typographical errors, actual inaccuracy of statement. Such features are undesirable in any text-book; in a book for beginners they are very regrettable. In this connection and in view of the concluding remark in the preface in regard to the manuscript and proofs, it is difficult to account for the presence of such statements as the following, namely:—"... if $y = x^2$, then $\frac{dy}{dx} = 2x$ means that the increase of y with respect to x^2 is $2x$, or that y increases $2x$ times as fast as x^2." Or "... the curves $y = x^2$ and $y = 4x^2$ are identical in shape. . ."

The chapter on alternating currents, except for a few obvious errors, will be found very instructive.

Chapter III. gives a very clear description of the manner in which alternating currents are transmitted along wires and this is followed by a very good explanation of velocity of wave propagation and of attenuation and wave-length constants. The nature and effects of reflections from free and closed terminals is also dealt with. There would be less obscurity and the value of this section would be greatly enhanced if certain symbols (*e.g.*, Z, I, A, etc.) were used exclusively for certain definite quantities, instead of assigning different meanings to them in different parts of the same chapter.

Chapter IV. deals, as far as the line is concerned, with the transmission conditions met with in practice. The various factors contributing to attenuation are clearly explained, as well as the phenomena of cut-off in a coil-loaded line. The tables of data relating to various classes of actual telephone circuits should be of great value to the student. Referring to Table III., the value of 5 micro-mhos for G is rather large. The same remark applies to the G of the cable circuit of Table I., page 69. The practical conditions would be more truly represented in this case by interchanging the leakances of the 200 lb. cable and the 200 lb. open wire. The proof (pp. 129, 130) of the design rule for loading-coil spacing is unfortunately very obscure for reasons similar to those noticed in Chap. III.

On the whole the book is good value and it is rather a pity that in its present form it requires to be read with some discrimination. The text is clearly and fully illustrated, although errors appear in both. An index adds to the utility of the work. A.M.

"Electrical Engineering Practice." By J. W. Meares, C.I.E., F.R.A.S., and R. E. Neale, B.Sc., Hons. (London). Volume II. Chapman & Hall, Ltd. 25/- nett.

This book, which is the second of a series of three volumes, contains a large amount of information on subjects which are of interest and importance to the electrical engineer, but which up to the present do not appear to have been adequately treated in other books on Electrical Engineering.

At the present time the question of using electricity instead of gas and coal for household purposes is exercising the minds of many people and in such a consideration this book is likely to prove a distinct help. It describes the essential features of the various popular systems of surface and conduit wiring and discusses their particular applications and disadvantages. In other chapters valuable information is given relating to electric lighting fittings and accessories. A most interesting chapter appears on electric heating, in which details of the construction and operation of all type of domestic heating appliances and commercial heating systems are reviewed. A comparison made between electrically heated equipment and similar fuel burning apparatus shows under what circumstances electricity is a serious rival of fuel for heating purposes.

A large portion of the book is devoted to a consideration of the transformation and conversion of electrical energy and although this subject has been previously dealt with extensively by other authors it will be found well worth reading.

The book is well printed and illustrated, and should make a useful addition to the library of those interested in power Electrical Engineering. H.C.J.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Batchelor, Major W. M.	Asst. Suptg. Engineer, E. District.	Suptg. Engineer, S.W. District.	1-10-27
Weaver, R. A.	Asst. Suptg. Engineer, London Dist.	Suptg. Engineer, N.Wales District.	7-8-27
Simmance, J. H.	Executive Engineer, E.-in-C.O.	Asst. Staff Engineer, E.-in-C.O.	27-6-27
Cheshire, F. W.	Executive Engineer, E. District.	Asst. Suptg. Engineer, E. District.	To be fixed later.
Brown, James	Executive Engineer, London District.	Asst. Suptg. Engineer, London Dist.	8-8-27
Calveley, W. H.	Assistant Engineer, E. District.	Executive Engineer, E. District.	8-7-27
Lonnon, W. U.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	8-7-27
Rattue, A.	Assistant Engineer, S.W. District.	Executive Engineer, S.W. District. (in place of Mr. A. C. Phillips, who refused promotion).	31-7-27
Burbridge, W. C.	Assistant Engineer, N. Wales Dist.	Executive Engineer, London District.	To be fixed later.
Cobbe, T.	Assistant Engineer, E. District.	Executive Engineer, E. District.	,,
Jackson, D.	Chief Inspector, Testing Branch.	Asst. Engineer, Testing Branch.	20-7-27
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Hawkes, D. J.	S.W. Class I., London District.	Inspector, London District.	2-8-27
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Kennedy, J.	S.W. Class I, Scot. West District.	Inspector, Scot. West District.	23-3-27
Kirkland, J.	S.W. Class I, Scot. West District.	Inspector, Scot. West District.	28-6-27
Ruffell, W. R.	S.W. Class I, Scot. West District.	Inspector, Scot. West District.	20-6-27
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Powning, S. H.	S.W. Class I., Radio.	Inspector, Rugby Radio Station.	10-12-26
Crank, F. G.	S.W. Class I., Radio.	Inspector, Devizes Radio Station.	30-3-27

PROMOTIONS.—continued.

Name.	Grade.	Promoted to	Date.
Woodhead, H. C.	S.W. Class I., Radio.	Inspector, Bodmin-Bridgwater Radio Station.	12-3-27
Ade, A. F....	S.W. Class I., Radio.	Inspector, Rugby Radio Station.	3-7-26
Cook, G. H.	S.W. Class I., Radio.	Inspector, Rugby Radio Station.	6-3-26
Lloyd, H. H.	S.W. Class I., Radio.	Inspector, Rugby Radio Station.	27-2-26
Symonds, A. E. J.	S.W. Class I., Radio.	Inspector, Northolt Radio Station.	28-3-27
Addis, C.	S.W. Class I., Radio.	Inspector, Oxford Radio Station.	16-7-27
Sutherland, J. C. C.	S.W. Class I., Radio.	Inspector, Stonehaven Radio Station.	12-6-26
Walker, N. M.	S.W. Class I., Scot. W. District.	Inspector, Scot. West District.	23-3-27
Copland, J. L.	S.W. Class I., Scot. W. District.	Inspector, Scot. West District.	22-8-27
Dolton, H. J.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-9-27
Hogbin, A.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	,,
Watt, J.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	,,
Rudeforth, S.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	,,
Bradley, T.	Probationary Inspr., London District	Inspector, London District.	,,
Sherriff, L.	Probationary Inspr., N.Wa. District.	Inspector, N.Wales District.	,,
Clibbon, H. A.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	,,
England, A. G.	Probationary Inspr., N.Wa. District.	Inspector, N.Wales District.	,,
Smithers, F. A.	Probationary Inspr., S.E. District.	Inspector, S.E. District.	,,
Cameron, C J.	Probationary Inspr., N.Wa. District.	Inspector, N.Wales District.	,,

DEATHS.

Name.	District.	Grade.	Date.
Livingstone, A. P.	Northern.	Inspector.	30-6-27
Burton, F. G.	London.	,,	14-8-27

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
Broomhead, A.	Assistant Engineer.	N.Mid. District.	S.E. District.	
Pattison, B. C.	Inspector.	N.Wales District.	E. District.	9-6-27

REVERSION.

Name.	From.	To.	
Chambers, L. W.	Asst. Engineer, S.Wales District.	Chief Inspector S.Mid. District.	At own request.
Phillips, A. C.	Exec. Engineer, South East District.	Assistant Engineer South West District	

RETIREMENTS.

Name.	District.	Grade.	Date.
Plummer, T.	N. Wales.	Superintending Engineer.	31-7-27
Greenstreet, R.	Testing Branch.	Assistant Engineer.	19-7-27
Smith, D.	Scotland East.	,,	4.8-27
Brown, G. H.	London.	Chief Inspector.	30-6-27
Holmes, W. E.	London.	,,	31-7-27
Hindmarsh, J. E.	Northern.	Inspector.	9-6-27
Taylor, J. M.	South West.	,,	10-6-27
Way, E.	South East.	,,	30-6-27

CLERICAL ESTABLISHMENT.

TRANSFERS.

Name.	Grade.	From.	To.	Date.
Adams, H. G.	H.C.O.	N.W. District.	Ireland N. District.	22-6-27

PROMOTION

Name.	Grade.	Promoted to	Date.
Dean, W. H.	C.O.	H.C.O. London.	12-8-27

OTHER CHANGES.

Name.	Grade.	District.	Cause.	Date.
Parish, G. J.	H.C.O.	Met. Power.	Superannuation.	22-7-27
Salter, E. J.	,,	London.	Death.	23-8-27

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Cable Balancing.
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Capacity Effects in Telephony—Wired and Wireless.
Carrier Wave Telegraphy and Telephony.
Change Over from an Old to a New Exchange Equipment.
Common Battery Manual Telephone System.
Common Battery Manual Signalling System.
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Development Studies.
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Fault Procedure at Automatic and Manual Exchanges.
Fire Alarm Systems.
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Long Distance Wireless.
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Modern Aspects of Electricity and Magnetism.
Modern Telephone Practice.
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Telephone Repeaters.
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The Construction of a Modern Balanced Cable.
The Economy of the Leclanché Cell.
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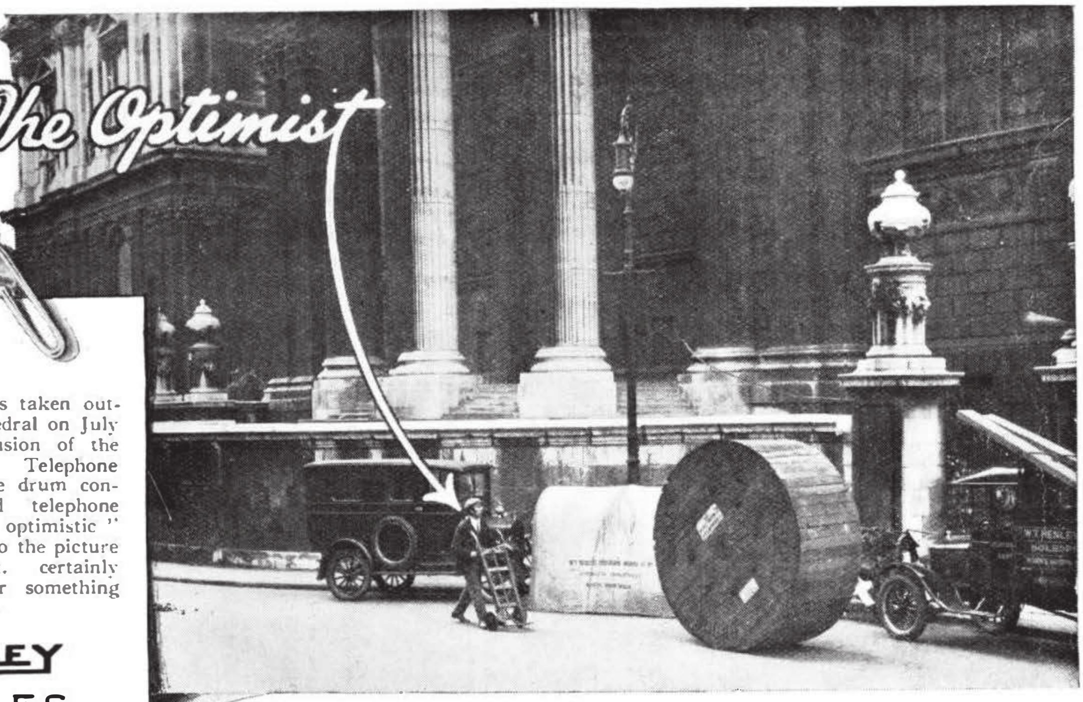

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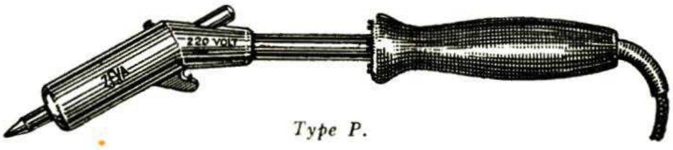

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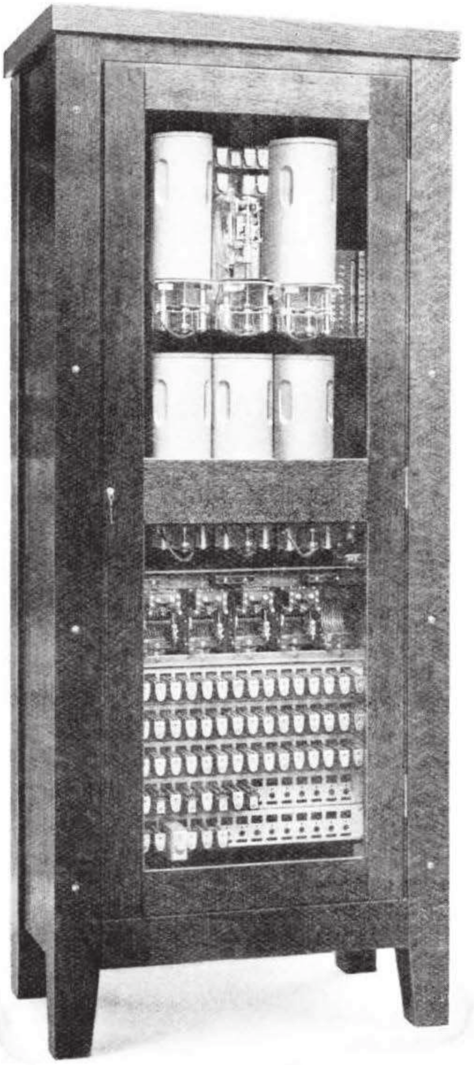

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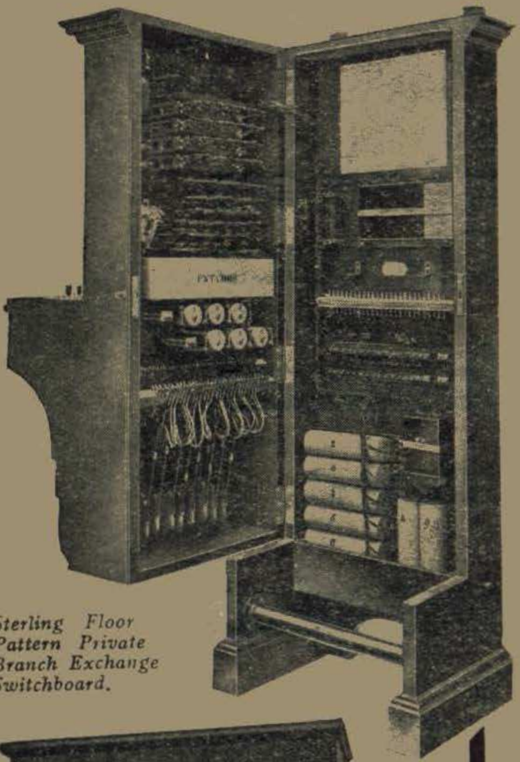
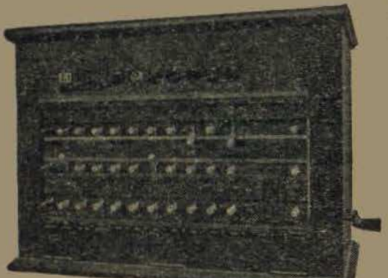
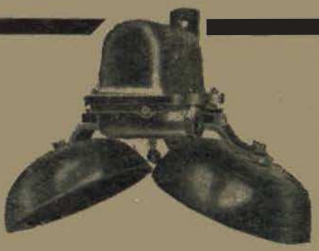


Sterling Floor Pattern Private Branch Exchange Switchboard.



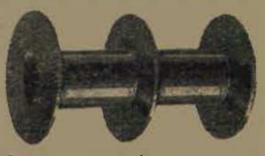
Sterling Table Pattern Cordless Switchboard for Private Branch Exchange.

Sterling Telephone Operator's Head Receivers —Double Earpiece Type.



Sterling Weather-proof loud Ringing Bell.

Sterling Telephone Operator's Head Receivers —Single Earpiece Type.



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THE
Post Office Electrical Engineers' Journal

LONDON AUTOMATIC SYSTEM.

INSTALLATION OF C.C.I. EQUIPMENT.

J. Radford, A.M.I.E.E.

PREVIOUS articles in this Journal have dealt with Coder Call Indicator working principally from the points of view of engineering and traffic facilities and with circuit operations.

It is thought, however, that both as a matter of historical interest and also to mark the completion of an engineering undertaking, considerable in magnitude and novel in character, some notes on the installation aspects of the work should be placed on record.

In order to meet the restrictions on space in this issue of the Journal the subject matter must be necessarily condensed, and no attempt will be made to describe in detail circuit operations, particulars of which are otherwise available.

It is well understood, of course, that the introduction of automatic working in London could not be effected by a simultaneous transfer from Manual to Automatic conditions of all the London exchanges. It was necessary, therefore, to provide means whereby, during a transition period extending over several years, traffic from the earlier automatic exchanges could be completed, as far as the automatic subscribers were concerned, on a full automatic basis, *i.e.*, that there should be no differentiation between the method employed by an automatic subscriber in making a call either to another automatic exchange or to a manual exchange.

For instance, Holborn was the first public automatic exchange to be opened in London and a Holborn subscriber is able to obtain a subscriber on any manual exchange in the London area in the same manner as would be employed to obtain an automatic subscriber on the Holborn or any other automatic exchange, *i.e.*, by dialling first the three letter code of the exchange required, followed by the four digits representing the wanted subscriber's number.

The completion of auto to auto calls needs no further comment, but it will be apparent that special arrangements are required at manual exchanges to receive calls automatically and to complete them manually.

The method adopted to meet this need was the provision of automatic equipment at every manual exchange, this equipment, in brief, receiving the calls from automatic exchanges, directing them to specially equipped positions, and displaying thereon, by means of lamps (see Fig. 1, Display Panel) the 4 digit number required, the operators at these special positions then completing the calls manually by the insertion of the plug of a specially equipped cord circuit, after making the usual busy test, into the multiple jack designated by the displayed number.

The junction arrangements adopted in London also provide for the routing of calls between

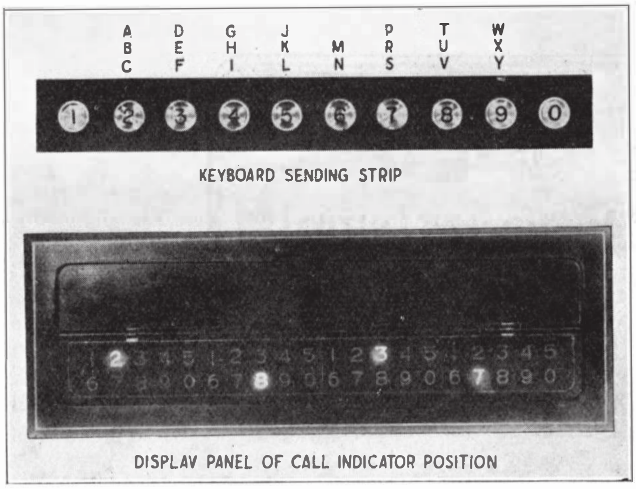


Fig. 1.—Keyboard Sending Strip and Display Panel.

manual exchanges in a similar manner, *i.e.*, the "A" operators order up the calls to "B" operators located on the cordless "B" Key-sending positions at the Tandem exchange in the Holborn building. These "B" operators assign a junction; the "A" operators connect their calling subscribers to the allotted junction and the "B" operators then set up the required number, exchange code and 4 digit number as in the case of auto to auto calls, by means of a Key set consisting of a strip of 10 keys, each key being numbered in the sequence **1-0** (see Fig. **1**, Keyboard Sending Strip). The call is then received and displayed at the required manual exchange precisely as in the case of an Auto to Manual call.

Numerous facilities are afforded by pilot and supervisory lamps, cancel, busy, release and special service keys, etc., but space does not permit more than passing mention of these.

Call Indicator Equipment.

Each incoming junction at Manual exchanges from Tandem or from automatic exchanges terminates on an Incoming Rotary Line Switch. When a junction is taken up, these switches hunt over a bank of 25 contacts in search of a disengaged outlet to a C.C.I. position. Various subsidiary portions of the equipment are also operated, more or less concurrently, such as Markers, Position Load Distributors, Decoding and Storage Relays and Position Trunk Relay Groups; all of these, with the exception of the latter, being freed and made available for further calls as soon as the display disappears, which happens immediately the operator at the C.C.I. position has inserted a plug into the required multiple jack.

Each C.C.I. position is equipped with 36 Cord Circuits, and associated with each Cord Circuit is a Rotary Line Switch.

The insertion of any one of the 36 plugs causes the associated R.L.S. to hunt in search of the Position Trunk Relay Group on which the call is standing and, this operation being complete, the through connection is established.

The main items of equipment installed at each manual exchange and the basis of provision are:—

Incoming Rotary Line Switch—
 Number provided in accordance with traffic requirements, not exceeding 50 per position.
Position Trunk Relay Groups—
 40 per position, Capacity 50.
Cord circuit R.L.S. and Relay Groups—
 36 per position.
Markers—
 5 per position.
Decoder Control Switch and Relay Group—
 1 per position.
Storing and Display Relay Group—
 1 per position.
Position Load Distributor—
 1 per 5 positions.

These items are mounted on specially designed racks, two racks being required normally

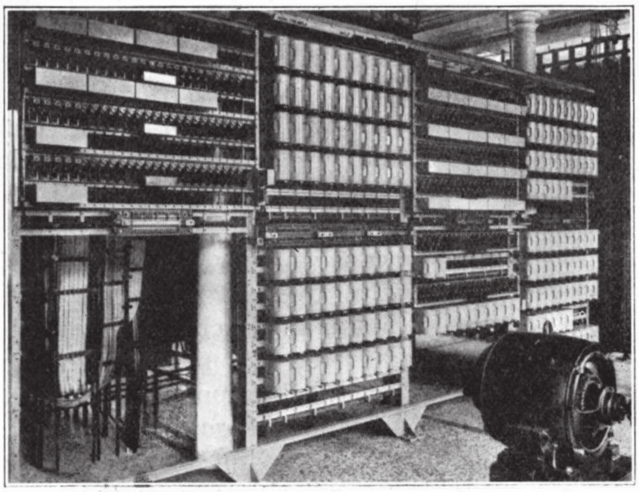


Fig. 2.—Four Racks at a 2-position Exchange.

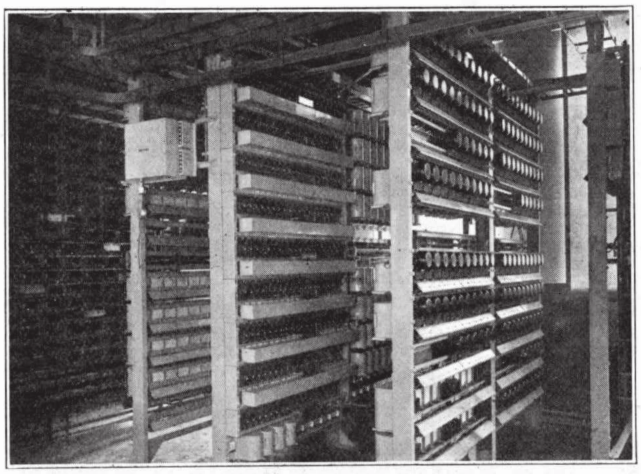


FIG. 3.—AN EXCHANGE WITH MORE THAN ONE LINE OF RACKS.

to accommodate the equipment for each position, the weight of each equipped rack being approximately half a ton. The height of the racks is 9′ 0″ and the gangway space between racks is 2′ 4″ between centres (wiring sides) and 4′ 0″ (apparatus sides).

Fig. **2** shows 4 racks in a single line fitted at a 2 position exchange. Fig. **3** shows the arrangement where more than one line of racks is installed, and Fig. **4** is a front view of a rack accommodating Cord Circuit R.L. Switches, and miscellaneous equipment.

In addition to the C.C.I. apparatus racks provision has to be made in the lay-out for the Distribution Fuse Panel (one per exchange) and for the I.D.F. The latter item is supplied and installed by the Department and comprises *n* Frames M.D.F. 0/240, the number of frames depending on the number of positions to be equipped, the usual basis being one frame per position.

Works procedure.

Active preparations for the installation of the work commenced in October, 1923, with a programme of 74 exchanges, the number of positions varying between 1 and 14, the total number of positions being 289, the exchanges being located in 7 Internal Sections of the London Engineering District and in 7 cases two exchanges are situated in the same building.

In addition to the contract work, a very considerable amount of rearrangement and new work was undertaken by the Department.

A separate specification was prepared for each exchange, but in view of the novel character of the work, the miscellaneous subsidiary requirements, and the need for allocating the respective portions of the work between the Department and the Contractors, and also in order to ensure co-ordination of the work and uniformity of practice, a set of instructions (Circular, Telephones C.C.I. No 1. Notes on Works Procedure) was compiled and issued for the guidance of all engaged in carrying out the work.

Following are the principal matters dealt with in this Circular, some of which will be dealt with more fully elsewhere in this article:—

Accommodation and Lay-out, Exchange Sketches, Surrender of positions, Type of position to be converted, Cord circuits, Position

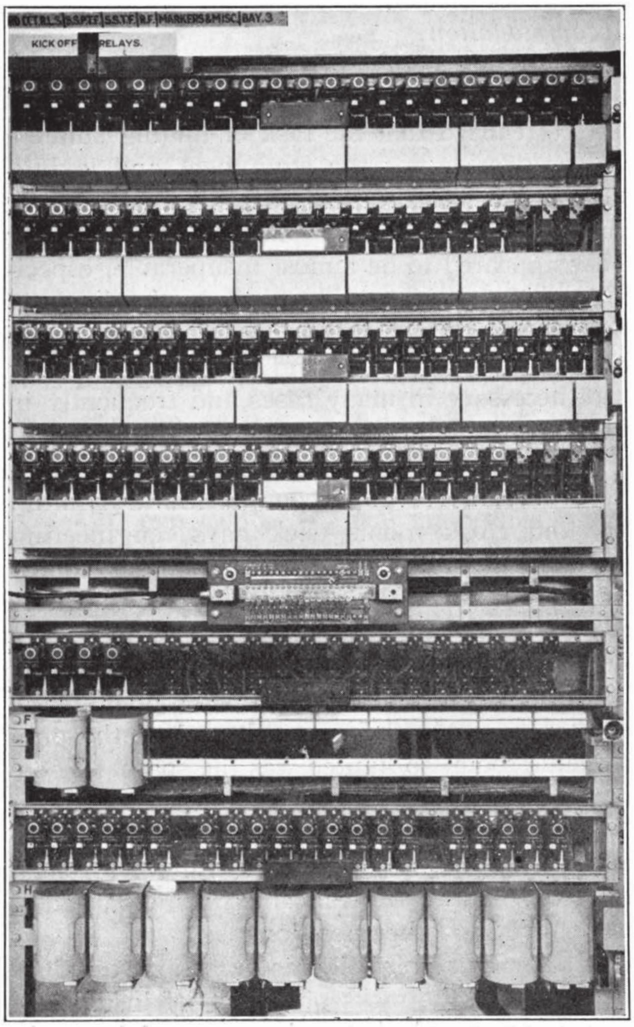

CCT.R.L.S. | S.S.P.T.F. | S.S.T.F. | R.F. | MARKERS & MISC. | BAY.3
KICK OFF RELAYS.

FIG. 4.—RACK FITTED WITH CORD CIRCUIT ROTARY LINE SWITCHES AND MISCELLANEOUS EQUIPMENT.

Equipment, Terminating points, Power Data, Position Battery Feeds, Interrupted Earth, Busy tone and Ringing supplies, Meters, Emergency arrangements, Special Service Circuits, Operators Routine Test Jacks, Routine Tester, Congestion and Night Alarm circuits, Coupling Keys, Auxiliary I.D.F., Cross Connections, Keyboard and Panel equipment, Display and Marker lamps, together with a complete list of all the exchanges with particulars of Position numbers and whether pure C.C.I. or combined CBOW/CCI.

Incorporated with this Circular were also drawings showing the change-over arrangements to be adopted in the case of combined positions, the Keyshelf and panel equipment, the cabling scheme, the position wiring scheme and the coupling key arrangements.

Accommodation.

To anyone acquainted with the congestion existing in many of the London exchanges it will be realised that the task of finding suitable accommodation for the equipment and laying-out the same to the best advantage was a task which presented many difficulties; these at times appeared to be almost insuperable, especially as, in quite a number of cases, the displacement of staff was the only practicable solution.

Structural alterations and floor strengthening were necessary in many cases and frequently in order not to delay the work measurements had to be taken and lay-outs planned in advance of the availability of the accommodation. Dining, rest and cloak rooms, sick bays, engineering and clerical offices were all laid under contribution, and although it would be an exaggeration to say that the paint had to be scraped from the walls in order to obtain the necessary space, it is true that in one case a narrow mantelpiece had to be removed from each end of the only available room, so limited was the space. There were also many cases where obstructions, such as electric light fittings, conduits, pipes, fire appliances, and also exchange equipment, such as power plant, batteries, cable runs, etc., had to be removed to other positions.

In a few cases also, it was necessary to reduce the height of the racks on acount of insufficient head room or of obstructions caused by main cable runs.

The usual procedure in planning the lay-out was for the exchange to be visited in company with the Contractor's representative and with the local engineering officer. The details obtained on these visits were embodied in exchange sketches, one of which was prepared for each exchange, and these sketches formed the basis of the Contractor's floor and cable runway plans. In practically every case the exchange sketches were submitted to the Office of Works for their decision on the question of floor strength.

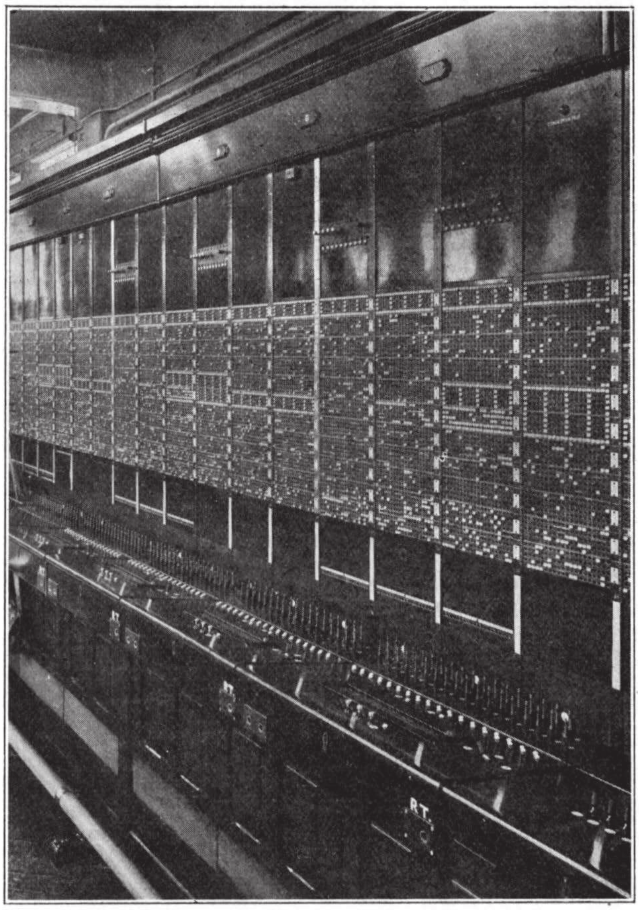


FIG. 5.—PHOTOGRAPH SHOWING POSITION EQUIPMENT.

Position equipment.

The equipment provided on each position is illustrated in Fig. 5, and comprises the following items, viz.:—

Keyboards and plugshelves.—Display panel, increase of cord circuits and supervisory lamps to 36 per position, decoder release, busy, coupling and special service keys, pilot, emergency and special service trunks busy lamps. In the majority of cases the equipment was accommodated on the existing keyboards.

Panel equipment.—Marker keys and lamps and Special Service overflow multiple.

Rear of Sections.—Operators' telephone circuit equipment.

Miscellaneous. — Manual emergency keys, Position Load Distributor change-over keys for bringing duplicate equipment into use on odd and even days, spare decoder keys in single position exchanges, congestion pilot lamps, operators' routine test jacks, etc.

Combined CBOW/CCI positions.

Where spare positions were available they were equipped at the outset as pure C.C.I. positions. In the majority of cases, approximately 200 positions, however, the existing C.B. order wire positions had to be converted for C.C.I. working whilst remaining in use as C.B.O.W. positions up to the time of transfer, and this necessitated the provision of change-over strips and extensive cabling re-arrangements. The strips were fitted in the most suitable positions having regard to the local conditions, the general location being either at the rear of the section, inside the rear of sections or in the cable-turning section.

Cable Scheme.

As a general rule the C.C.I. equipment is located in the apparatus room, and this involves a cable run between the apparatus room and the manual switchboard. In order to avoid the Contractors running cables over existing runs, and to facilitate the work generally, it was decided that the Department would provide the main cabling between the C.C.I. equipment and the manual board, the terminating points of these cables being on the C.C.I. I.D.F., fitted as near the apparatus as possible, and connection strips fitted in the cable-turning sections. Approximately 100 wires per position were provided between these two points, 40 of these being required for the display lamp circuits.

The I.D.F. in addition to serving as a handing over point for the Contractor's and the Department's cabling also provides cross connection facilities for the outlets from the I/C R.L.S. shelves to the P.T.R. groups, and for various miscellaneous services such as Special Service and Position Load Distribution circuits. In some cases, owing to insufficiency of floor space, it was necessary to provide vertical extensions of the I.D.F's. and in others, to provide separate locations for portions of the frame.

Drawings.

In addition to many miscellaneous sketches produced by the Department, the Contractors furnished circuit and other drawings to the number of approximately 120 for each exchange. Changes during the progress of the work, circuit modifications, etc., necessitated many changes of drawings (the issue number of one drawing being 30), so that approximately 25,000 drawings were furnished by the Contractors and distributed *via* the District Office to the various Engineering Sections and thence to the individual exchanges.

City Trial Installation.

As was more fully described under "Trial Equipment" in Mr. Hedley's article on Mechanical Tandem Exchange" (*I.P.O.E.E. Journal,* Oct., 1927), an experimental installation was provided at City Exchange in December, 1925, and remained in use until the early part of 1927.

The installation comprised one position on the City "B" suite, fully equipped as a C.C.I. position, and two cordless "B" Key-sending positions fitted temporarily in the City Manual Switchroom.

Various types of regular and artificial traffic were handled at these positions and as a result of the experience gained numerous circuit modifications were decided upon, these modifications being subsequently carried into the regular C.C.I. equipments at all the London Exchanges.

Additional Work.

The modifications referred to involved both additional circuit arrangements and re-arrangements of existing ones and portions were carried out by the Department and the Contractors respectively.

The engineering of these modifications during the progress of the main works was a problem which necessitated close attention to detail and co-ordination, especially as in some cases the work in connection with as many as six modifications was in progress in the same exchange at the same time, and running concurrently with the main installation work.

Distribution of Traffic.

It will perhaps be convenient at this stage to set out the traffic and engineering facilities and requirements which, in combination, were specified in order to afford the most efficient means for the regular distribution of incoming junction traffic worked on a Call Indicator basis.

The principal desiderata were as follows:—

(1) The distribution of calls over all the positions, in cyclic order, irrespective of the exchange of origin or of the number of Call Indicator Positions.

(2) The distribution of calls, as in (1), over any number of positions in an exchange, irrespective of the number of positions which may be open.

(3) The distribution of calls, as in (1), without pre-determination of the particular position or positions which are to remain open for normal concentration or other purposes.

(4) The elimination of the possibilities of traffic congestion unless and until all the positions are fully loaded at one and the same time.

(5) The ability to equip additional positions for C.C.I. working, to meet development requirements, without reference to the direction of growth of the suite of positions.

(6) The ready adjustment of the operating staff to meet the traffic requirements at any time.

(7) The relative simplification of the cross connecting arrangements.

(8) The reduction of complicated circuit arrangements, to a minimum.

(9) The avoidance both of the segregation of Tandem traffic and of its consequent distribution to certain pre-determined positions.

(10) The ability to place any C.C.I. position out of commission, either for engineering or traffic reasons, without effecting the general distribution of traffic over the other positions.

(11) The provision of sufficient outlets from each I/C R.L.S. shelf, this being done if necessary by the provision of means whereby the number of outlets, which are subject to physical limitations, may be augmented.

(12) The provision of means to indicate to the traffic staff when the opening of additional positions is necessary.

(13) The provision of some ready means whereby additional positions may be opened by the traffic staff as and when the need arises.

(14) The maintenance of approximately the same standard of service at all C.C.I. exchanges, irrespective of the number of C.C.I. positions or of the size of the junction groups.

The majority of the foregoing facilities were specified at the outset, but the need for others was demonstrated during the progress of the work, and also as a result of observations on the City experimental installation.

It became necessary therefore to make a complete investigation into the question of traffic distribution as effected by the operation of I/C R.L.S. and Position Load Distributor Switches.

The results of this investigation are incorporated in another special circular (Circular, Telephones C.C.I. No. 2), which deals with the cross-connection arrangements to be adopted to produce the conditions previously set out.

Having arrived at conclusions respecting the methods to be adopted for cross-connecting the incoming junctions to the I/C R.L. Switches, and the outlets from the I/C R.L.S. Shelves to the P.T.R. Groups, schedules were prepared and issued to the District showing the actual cross-connections to be carried out at each exchange. This was done in order to preserve uniformity of practice at each exchange and also to ensure co-ordination with the officers dealing with the trunking and grading arrangements of the juctions incoming at the C.C.I. Exchanges from M.T. Exchange.

Testing out.

The ordinary physical and electrical tests were carried out during installation as far as possible. On completion of installation, however, it became necessary to test the equipment as a whole and as nearly as possible under working conditions.

The equipment at M.T. exchange was not available for this purpose, so it was decided to reproduce the M.T. conditions by specially designed circuit arrangements.

Testing equipment, assembled and wired in a unit form, was made up in the C.T.O. workshop and was designated Tester " X."

This Tester is designed:—

(1) To typify the conditions which will obtain at M.T. exchange in respect of calls to C.C.I. exchanges, including coding and sending functions, and

(2) To set up these calls in the C.C.I. equipment and to test the operation of the latter including all facilities under regular traffic conditions.

Concurrently with the production of this Tester complete testing out instructions were compiled and embodied in a special circular (Circular, Telephones C.C.I. No. 5, Testing Out Instructions).

The circular contains full instructions regarding the tests to be applied and the method of applying the tests, but following is a brief summary of the more important tests.

Call through tests.

These are the final tests of the equipment and are carried out when the installation is entirely completed with all cross connections run. They are designed to prove that the equipment as a whole functions correctly under working conditions for all classes of calls and through every traffic channel in accordance with the specified engineering and traffic requirements.

The tests on a single call basis comprise verification of the following conditions, viz., Ringing Tone, Ringing Trip, Supervision, Metering, Wrong disconnect, Regular Pilot and Recall, Special Service Key and Multiple, Manual Emergency, Markers, Position Load Distribution, Busy tone and flash, Decoder release, and Decoder Control Switch.

After completion of the single call through tests, a load test is applied, the object of which is to prove that the equipment as a whole functions correctly under continuous load conditions, irrespective of the number of positions, the volume of traffic, and of the exchange of origin of the traffic.

The load test is not primarily concerned with the display of correct numbers and in the initial stages of the test one setting of the digit keys suffices, resulting in the same number being repeatedly displayed. As the tests proceed, however, the setting of the digit keys is altered, resulting in numbers being displayed corresponding to the particular setting of these keys.

The utility of the Tester having been demonstrated in practice, several more were constructed in order that testing out might proceed simultaneously at different exchanges. The circuit arrangements as originally designed remained substantially unaltered and the Tester proved to be an invaluable aid to the satisfactory completion of the work.

Opening of the C.C.I. service.

As the engineering work at each exchange was completed, the equipment was handed over to the Traffic officers. Artificial traffic trials were then carried out and on the satisfactory completion of these the C.C.I. equipment was at once used for regular traffic between Manual Exchanges *via* Tandem.

The first 20 exchanges were opened simultaneously on the 18th August, 1927, the remaining exchanges, in number varying from one to four at a time, being opened on various dates until the 3rd November, 1927, when the last two exchanges in the first London programme were cut into service, the whole of the 74 exchanges thus being ready for the opening of Holborn Automatic exchange (an essential condition) which took place on the 12th November, 1927.

This is not the occasion on which to record judgment on the performance of the equipment, as this will no doubt be done on a future occasion when more experience under actual working conditions is available.

It will no doubt be conceded that the engineering of a work of this character and magnitude, over a period of four years, has been a task which has made a heavy demand on the initiative and energy of all officers concerned and it is gratifying to record its successful accomplishment.

The whole of the C.C.I. equipment provided under contract was manufactured and installed by the Automatic Telephone Manufacturing Co., Ltd., Liverpool.

HOLBORN.

HOLBORN Automatic Exchange, the first in Europe provided with Director equipment, was successfully brought into service at midnight on the 12th November. The installation was carried out by the Automatic Telephone Manufacturing Co., of Liverpool.

The opening of this Exchange is a further step forward in the standardisation of the Department's automatic system and is a milestone in the history of telephony in this Country. The problems of equipment and design in connection with the London system were so numerous that an Equipment Committee was set up at Headquarters under the late Mr. M. Ramsay, and later under Mr. W. J. Bailey, to control conditions so as to work towards an ultimate standardisation; special and significant interest consequently attaches to the operation of the Holborn equipment. Telephone Administrations all over the world are interested in the conversion of the London area to automatic working, chiefly because of the special conditions that prevail, and telephone officials from many different countries have consequently visited the Exchange during the installation.

The Holborn equipment was installed concurrently with that of the Tandem Exchange and with the installation of Call Indicator equipment at 74 Manual Exchanges in the area, the completion of which was necessary before the Exchange could be brought into service. The Tandem exchange is described in an article in this Journal for October by Mr. J. Hedley, and the Call Indicator scheme in this issue by Mr. J. Radford.

The Exchange is located in the same building as the Tandem Exchange at 270, High Holborn. The automatic apparatus occupies the first floor, the manual equipment being situated on the top floor, as shown in Fig. **3** of Mr. Hedley's article in the October Journal. The Exchange has a capacity for 10,000 lines and the following schedule of the equipment installed and brought into use at the transfer will convey some idea of the magnitude of the work.

Line Switches...	9,400
" A " digit Selectors	188
Directors	232
1st Code Selectors (Auto)	1,173
Do. (from Manual Positions)	50
2nd Code Selectors	1,065
3rd Code Selectors	347
1st Numerical Selectors	1,633
Do. (from Manual Positions)	27
2nd Numerical Selectors	1,932
PBX Final Selectors (2/10 lines) ...	1,680
Do. (11/20 lines) ...	180
Do. (over 20 lines) ...	26
Outgoing Junctions	1,400
Incoming Junctions	1,900
Incoming Trunk Junctions	80
Senders (Keysending " B " Positions)	50
Coders (Call Indicator Traffic) ...	80
No. of Lines working at transfer ...	4,739

Owing to the large number of P.B.X. subscribers in the Holborn area, regular Final Selectors are not installed; subscribers with single lines are accommodated on P.B.X. (2/10 lines) Final Selectors.

The Holborn power plant is described in an article by Mr. P. B. Frost in the April issue of this Journal.

The testing out of the equipment prior to acceptance was a prodigious task, involving the use of special testers, designed at Headquarters, descriptions of several of which have already been published in this Journal by Messrs. W. Prickett and H. S. Smith, with the object of reducing the number of manual operations to a minimum and thus speed up the work. The number of testing operations performed during testing out was of the order of 2,500,000, the work being carried out by the Holborn staff under the direction of Headquarters officers.

The transfer was accomplished by the simultaneous withdrawal of heat coils from the protectors in the manual exchange and the removal of wooden strips from the protectors in the Automatic Exchange. Prior to the transfer subscribers were given practical demonstration in the use of the dial and the significance of tones by the use of special demonstration sets constructed in the Training School, located in the Automatic Exchange, to which the lines were extended. In addition, subscribers have been provided with a specially prepared pamphlet explaining the features and operating procedure of the system.

Some technical details of the system will be given in a subsequent issue.

C.W.B.

BRIGHTON AREA.

TRANSFER TO AUTOMATIC WORKING.

J. RADFORD, A.M.I.E.E.

AUTOMATIC working was inaugurated in the Brighton Area by the simultaneous closing of 7 manual exchanges and the opening of 5 automatic exchanges at midnight on the 12th November, 1927.

The traffic "all clear" signal was given at 11.57½ p.m., the old exchanges were cut out by 11.59½ p.m. and the new exchanges were cut into service by 12.5 a.m., the whole transfer operations thus occupying a period of 7½ minutes. In view of the complex exchange system in this area and the large number of lines involved, approximately 8,000, this is regarded as very satisfactory, especially as all concerned in the transfer had been instructed that accuracy, and not speed, was of primary importance.

The old exchanges closed were Central (Ship Street), Post-Brighton (Ex Corporation) and Kemp Town, together with the old exchanges replaced by new exchanges, particulars of which are shown in the subjoined table:—

			Multiple	
	D.E.L.	Stations.	Initial Equipment.	Capacity.
Central ...	3337	4952	4700	6900
Hove ...	2916	3966	4200	6200
Preston ...	727	888	1000	1400
Portslade ...	274	324	400	600
Rottingdean	98	119	200	400
Southwick...	*	*	200	400
	7352	10249	10700	15900

Immediately after transfer the number of P.G's. observed was 54, giving a percentage of 0.7 on the 7352 direct exchange lines transferred. The faults giving rise to these P.G's. were quickly localised outside the exchanges and were dealt with in due course under ordinary fault procedure.

The usual engineering tests (condenser tests) were carried out from the Main Frames forthwith and these were completed by 5 a.m. on the 13th November.

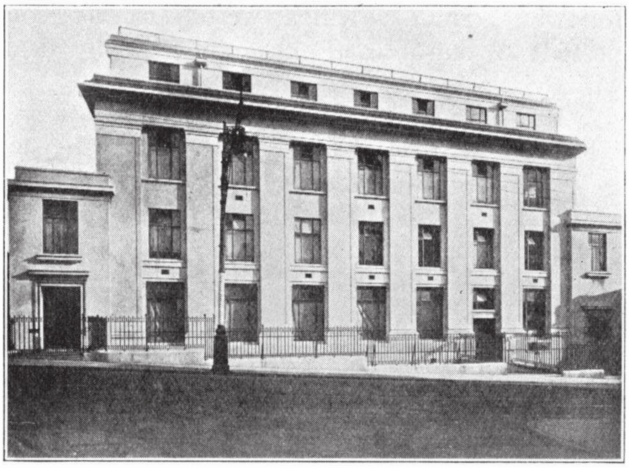


FIG. 1.—CENTRAL AUTO. EXCHANGE, BRIGHTON.

The exchange equipment (Siemens No. 16) has been installed in new buildings in each case, a requirement in connection with most of the buildings being that they should conform as far as possible with the residential character of the districts in which they have been erected.

Fig. 1 shows the Brighton Central Exchange building, which also provides sorting office and bag-cleaning accommodation, and **Fig. 2** shows

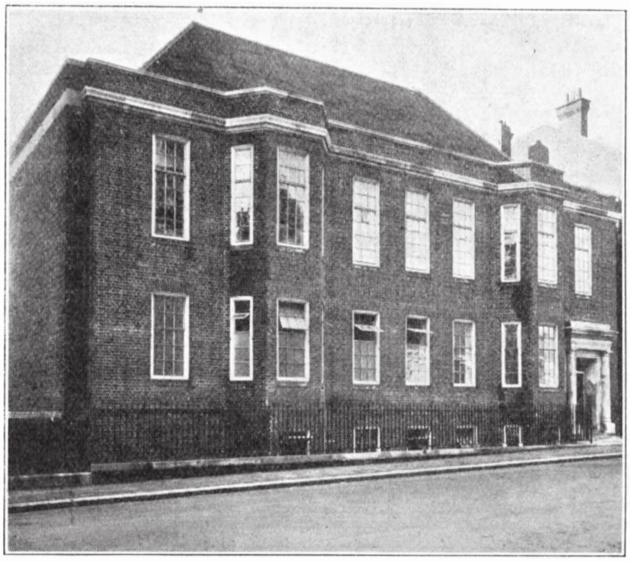


FIG. 2.—HOVE AUTO. EXCHANGE.

* *See separate paragraph re Southwick.*

the Hove building. The latter photograph illustrates the extent to which the requirements regarding conformity with the residential type of building have been met.

Correction of area transfers were carried out at the same time as the main transfer, the following circuits, which were formerly connected to out-of-area exchanges, being dealt with, viz.:—

Brighton to Hove	77
,, to Preston	37
Post-Brighton to Hove	269
,, ,, ,, Preston ...	112
Hove to Brighton	6
,, ,, Portslade	2
,, ,, Preston	8
Preston to Brighton	1
Total	512

The number of trunks and junctions dealt with was 654, made up as follows:—

Manual I/C	69
O/G	73
B/W	68
Automatic	444
Total	654

The multi-exchange area comprises two main exchanges, Brighton and Hove, and 4 satellite exchanges, two of which, Preston and Rottingdean, are satellites on Brighton, the remaining two, Portslade and Southwick, being satellites on Hove. The trunking scheme for the area is shown in Fig. 3.

Each of the satellites is equipped with discriminating selectors and repeaters. Local calls are thus completed within the exchange, but all other originating traffic is dealt with by the

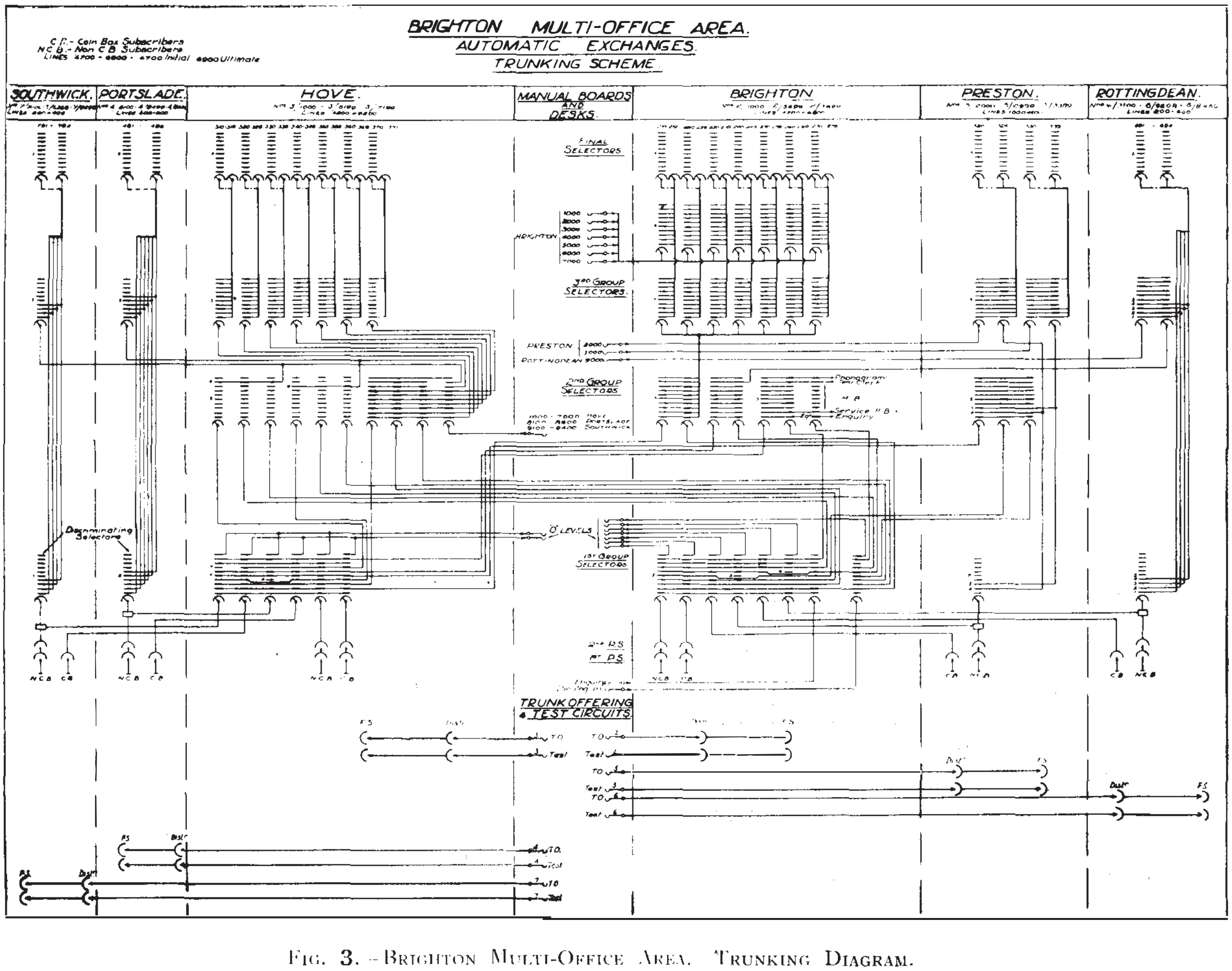


FIG. 3.—BRIGHTON MULTI-OFFICE AREA. TRUNKING DIAGRAM.

associated incoming selectors at the respective parent exchanges.

The numbering scheme, known as the "Brighton Scheme" (this area being the first in which it has been used), is similar to the ordinary full 5-figure scheme as far as the switching operations are concerned. It differs, however, in one important respect, viz., that, instead of the full 5 digit number being dialled by the subscriber, the exchange name takes the place of the 1st, or ten-thousands, digit. The exchange names appear on the dial number plate, as shown in Fig. **4**, each exchange name being associated with a particular digit, *e.g.*, Brighton 2, Hove 3, etc.

The subscriber therefore dials first the name of the exchange required and then the 4 digit number. It will be obvious, of course, that in dialling, say, Brighton 2345, the number actually dialled is 22345; similarly Hove 4567 would be 34567.

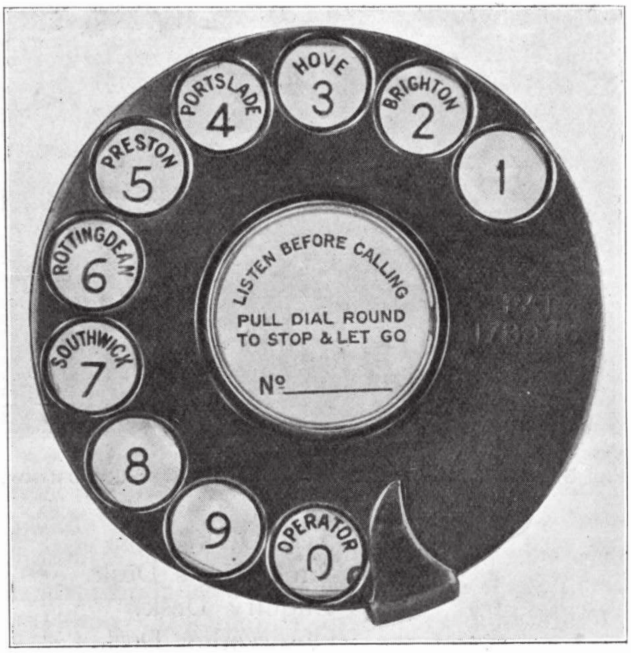


FIG. **4**.—"BRIGHTON" DIAL.

Subjoined is a schedule showing full details of the numbering scheme, initial and ultimate, the initial digit, as stated above, corresponding to the exchange name, the 4 digit numbers only appearing in the directory.

Exchange.	Numbering Scheme.		
	Initial.	Ultimate.	
Brighton ...	2/1000—2/5699	2/7899	Main Exchange.
Hove	3/1000—3/5199	3/7199	,, ,,
Preston ...	5/2000—5/2999	5/3399	Satellite on Brighton.
Portslade ...	4/8100—4/8499	4/8699	,, on Hove.
Rottingdean ...	6/9100—6/9299	6/9499	,, on Brighton.
Southwick ...	7/9100—7/9299	7/9499	,, on Hove.

Although the instructions to subscribers are quite distinct regarding the dialling of the Exchange name on the dial before the 4 digit number, many cases of incomplete dialling occurred owing to subscribers failing to observe this procedure.

On the general question of subscribers' mis-operation it is considered that too much importance cannot be attached to comprehensive and intensive publicity and to the education of telephone users before the transfer, in order to ensure the minimum amount of abnormal congestion on the first few days following transfer, due to incorrect dialling methods, curiosity calls, non-recognition of distinctive tone signals, etc.

The common manual board for the area is situated in the same building as the Brighton automatic exchange and comprises the following positions:—

Position 1. Key sending position. Spare unequipped.
,, 2. Key sending position. Equipped. On this position terminate the circuits incoming from the London Toll Exchange.
,, 3. Service P.B.X. position.
,, 4 & 5. Jack ended junction positions.
,, 6-23. "A" positions. For subscribers' O level traffic.

The outgoing junction multiple comprises 120 circuits with V.E.S. and 260 circuits without V.E.S.

In addition, the following service desks have been provided:—

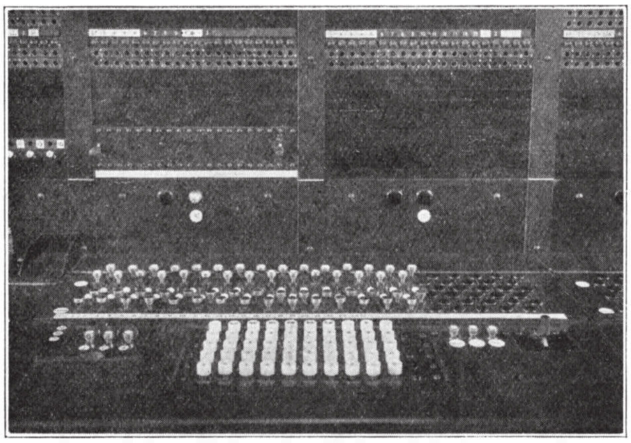


FIG. 5.—BRIGHTON. MANUAL BOARD. KEY-SENDING POSITION.

6	Position	Test Desk.
2	,,	Supervisor's Desk.
6	,,	Enquiry Desk.
1	,,	Observation Desk.

Both the testing and observation arrangements for the whole area are centralised on the Brighton Test Desk and Observation Desks respectively.

Fig. **5** shows the Keyboard equipment of the Cordless "B" Key-sending position.

The remaining illustrations may be briefly referred to as follows:—

Fig. **6**. General view of Brighton Central Exchange, showing group selectors on left, portion of protector side of M.D.F. at end of aisle, and rear view of a 1st Preselector Rack and sectional I.D.F. on right.

Fig. **7**. General view of Preston Exchange showing M.D.F. on left, 1st P.S. Rack bottom centre and 2nd Selector Rack on right.

Fig. **8**. General view of Portslade Exchange, showing Power Panel and Interrupter on left followed by a partially equipped Final Selector Rack, a 1st P.S. Rack and a partially equipped 2nd P.S. Rack.

As a matter of interest it might be mentioned that the controlling officer directing the transfer operations was located in a room remote from the automatic switchroom. The necessary instructions to the staff engaged on the transfer were therefore given over the various control circuits radiating from the Control room without risk of disturbance or interruption. A listening-in circuit connected across the controlling officer's telephone was provided for the use of the supervising officers in the automatic switchroom.

The usual abnormal traffic conditions arose on the Monday morning, the first working day after the transfer. Subscribers' dialling and other difficulties were handled very expeditiously by the staff located at the 1st Selectors and by the early afternoon the congestion had disappeared. There was a perceptible recrudescence on the following morning, but in no case was there any reason to doubt the adequacy of the provision made either as regards the number of switches or the trunking arrangements; in fact, the exchanges appear to have settled down to normal working conditions in a remarkably short time.

The complex external plant conditions, the exhaustion of manual plant in the various exchanges from time to time, necessitating a large number of lines being connected to out-of-area exchanges, and the concurrent work in connection with development schemes have, together, produced a very complicated network of subscribers' cables and open wires and in the

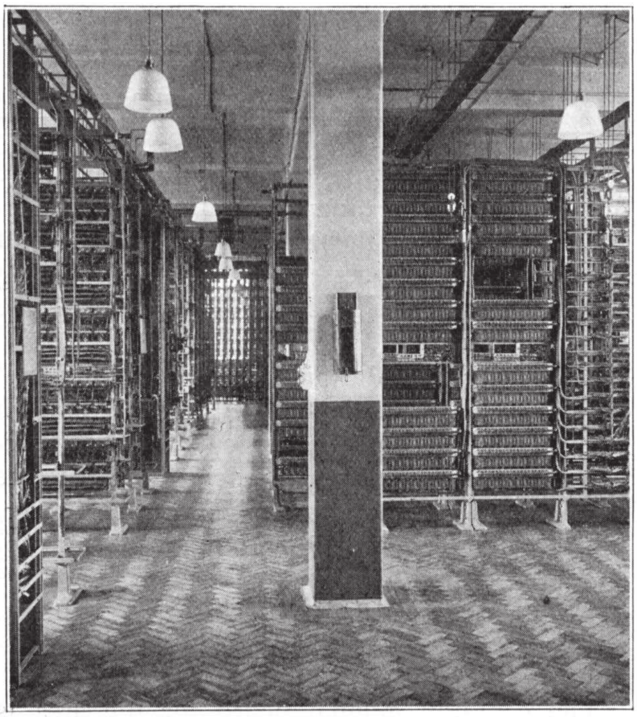


FIG. 6.—BRIGHTON. GENERAL VIEW OF AUTO. SWITCHROOM.

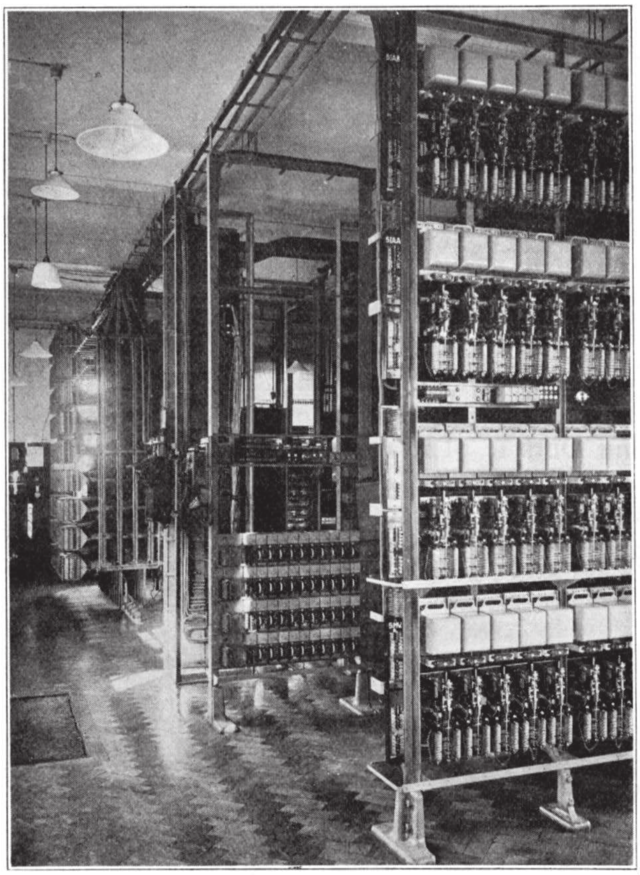


Fig. 7.—Brighton. General view of Preston Auto. Switchroom.

absence of adequate cable capacity the use of a large number of change-over strips was required. The local engineering officers recognised from the outset that these strips would have to remain in use for a considerable period and that the large amount of connecting and disconnecting for the purpose of testing out the system, particularly as regards the call through tests, would be much facilitated and risk of interruption to service avoided by making a substantial job of the change-over arrangements. It was therefore decided to instal the strips and cabling in as permanent a manner as possible, having due regard, of course, to their ultimate recovery. The wisdom of this course, as distinct from the employment of purely temporary measures, was evidenced both during the progress of the work and at the transfer. The ironwork supports for the strips were designed with a view to their further use on recovery at other exchanges.

Southwick Exchange. At the date of writing, Southwick Exchange had not been transferred to automatic working owing to delay in building operations. The particulars of this exchange have, however, been included in this article for convenience of record and reference, as the exchange will be opened during December, 1927.

In view of the large number of successful transfers taking place nowadays, no claim is made for anything of a special nature in the way of achievement but, at the same time, it should be recorded that the success attending this transfer was only made possible by the most careful organisation of the arrangements by the local supervising officers and by the thorough and efficient manner in which all ranks responded to demands made upon them.

The writer's thanks are accorded to Messrs. Siemens for the photographs accompanying this article.

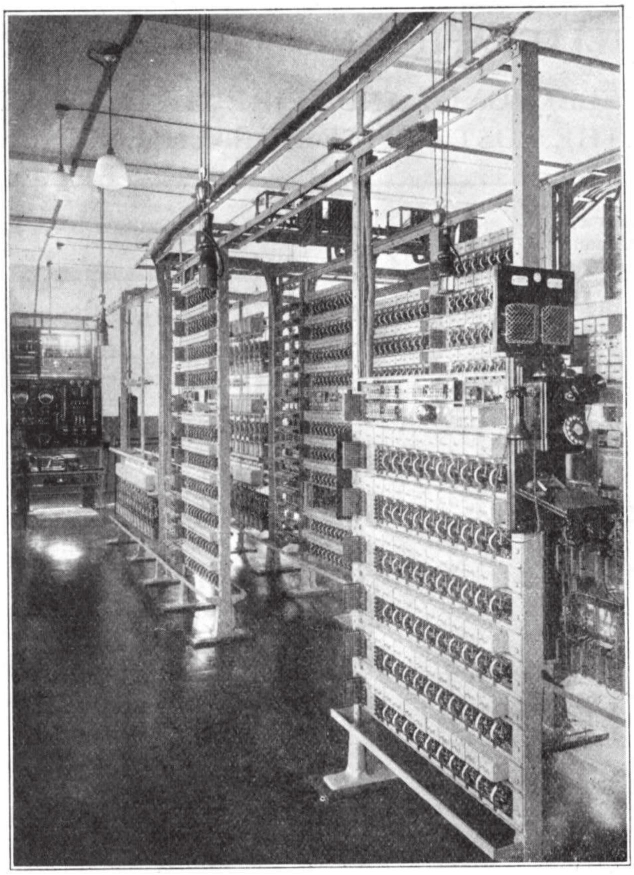


Fig. 8.—Brighton. General view of Portslade Auto. Exchange.

EXETER AUTOMATIC AREA.

THE above area, which comprises the Exeter Main exchange installed in the new wing of the old exchange premises in Castle Street, Exeter, and the Topsham Satellite exchange, which is housed in the old exchange premises at Topsham, was transferred to automatic working at 2 p.m. on 19th November, 1927.

The equipped capacity of the main exchange is for 2,100 lines, with an ultimate of 3,500. The satellite exchange has an initial equipment of 200 lines, but floor space is available for 400 lines.

The change-over was successfully carried out in the short period of 1.5 minutes, the number of working lines in the area at the transfer being:—

		Exeter.	Topsham.
Subscribers	...	1689	96
Junctions	...	104	26

The manual board suite consists of 15 positions designed to handle Enquiry, Trunk and "0" level traffic. Dialling-in facilities have been provided from 26 exchanges scattered over a wide area comprising towns in Devon, Somerset and Dorset. The manufacture and installation of the exchange equipment was carried out satisfactorily by the General Electric Company, and is up to the usual Post Office standard.

A.B.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 30TH SEPT., 1927.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
553,707	537	4,197	52,029	139	London	23,504	61,792	2,069,002	134,878
69,132	2,133	20,927	63,306	1,760	S. East	3,871	43,831	168,355	15,226
73,800	4,373	30,059	51,825	2,457	S. West	17,161	10,474	131,462	60,766
57,077	5,901	34,605	54,657	4,781	Eastern	22,495	35,195	90,246	73,853
90,916	8,752	44,173	56,059	3,661	N. Mid.	23,247	48,796	223,502	120,472
71,630	4,807	29,057	67,755	3,769	S. Mid.	13,108	21,171	152,451	88,987
55,579	4,704	29,258	50,606	2,786	S. Wales	5,838	25,405	103,408	69,824
96,576	8,292	25,818	48,205	4,452	N. Wales	12,946	40,970	235,370	60,271
148,791	1,590	17,057	42,871	2,636	S. Lancs.	13,087	75,823	439,469	46,339
87,943	6,186	30,731	45,188	3,065	N. East	10,573	43,639	209,531	58,581
60,219	3,515	23,713	36,165	2,163	N. West	8,194	32,074	148,251	37,884
45,043	2,468	15,867	23,937	2,777	Northern	4,614	14,361	98,362	50,054
20,402	4,726	7,832	13,332	353	Ireland N.	130	2,302	36,766	1,215
61,587	5,492	24,809	35,636	1,486	Scot. East	3,635	11,991	142,006	47,277
83,364	7,344	24,099	41,834	922	Scot. West	12,147	24,383	211,887	35,117
1,575,766	70,820	362,202	683,405	37,207	Totals.	174,550	492,207	4,460,068	900,744
1,552,329	70,324	360,234	671,744	37,350	Figures at 30th June, 1927.	173,149	484,449	4,349,216	894,575

MANCHESTER AUTOMATIC SCHEME.

A. S. A. JOHNSON, A.M.I.E.E.

AS Manchester will be the first provincial telephone area in which the Director system will be used—although Birmingham will follow it very closely—a preliminary outline of the scheme together with some notes on certain features of the proposed trunking arrangements may be of interest.

Plan of Area.—Fig. 1 shows the proposed lay-out of the area under automatic conditions. The circle enclosing the area is 14 miles in diameter, with its centre at Manchester Town Hall, and the plan shows the approximate positions of the 37 automatic exchanges which, on the basis of the present estimate of develop-

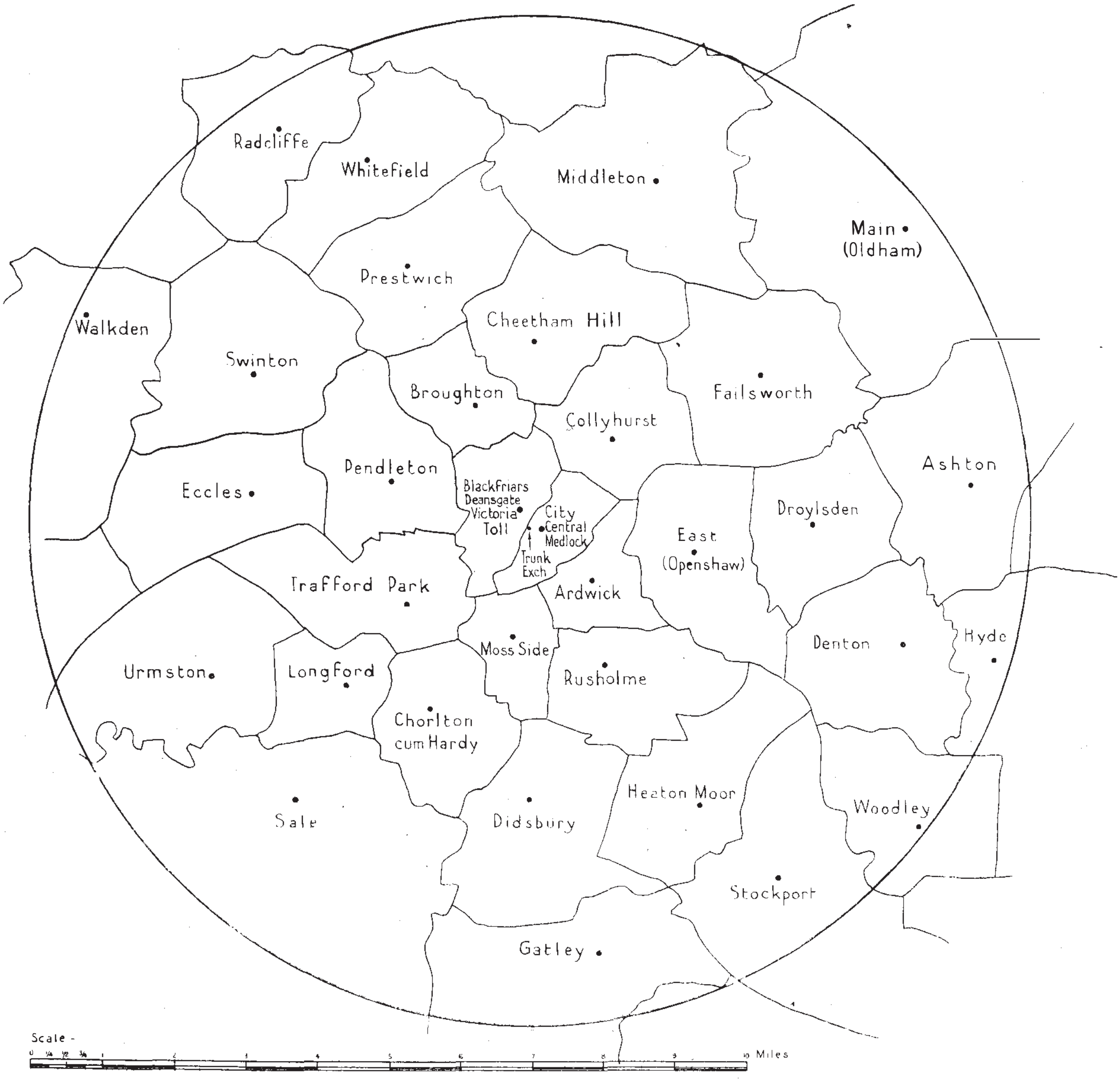


FIG. 1.—MANCHESTER AUTOMATIC AREA.

ment, constitute the most economical method of serving the area. The requirements of the central portion of the city will be met by means of six 10,000 line exchanges, three of which—to be known as Blackfriars, Deansgate and Victoria—will be located in a new 7-story building at Chapel Street; the other three—City, Central and Medlock—will be accommodated in the existing York Street building which now contains the City and Central manual exchanges.

It is anticipated that the total capacity of the automatic exchanges in the area will ultimately amount to not less than 150,000 subscribers' lines, and an extensive network of junctions will be required to link up these exchanges.

Programme of Work.—It will be appreciated that for various reasons the conversion of an area of this size and character cannot be completed in one operation, but the programme for Manchester provides for a substantial proportion of the scheme being undertaken within a comparatively short period, as will be seen from the following summary.

Initial Stage.—Three new exchanges of the Director type will be brought into use at Ardwick, Collyhurst and Moss Side. The buildings for these exchanges are in course of erection and the manufacture of the equipment will be commenced very shortly. The building at Chapel Street, already referred to, will accommodate in the first place an auto-manual board to deal with Toll calls and enquiries from the automatic exchanges. The auto-manual board will include a number of order wire "B" positions equipped with key-sending facilities, for keying-up large blocks of traffic from City, Central, and certain other manual exchanges to the automatic exchanges. Other traffic from manual exchanges to the automatic exchanges will be "dialled-in," either from Chapel Street, or from the originating exchange itself where direct dialling-in junctions are justified. Arrangements will be made to provide call indicator positions at the City and Central manual exchanges for the receipt of calls directly from the automatic exchanges, the code and number being dialled by the subscriber as for an automatic call. Other manual exchanges in the area will not be equipped with call indicator positions during the initial period of automatic working; automatic subscribers requiring these exchanges will obtain connections *via* the auto-manual board.

Main Conversion Scheme. — The major portion of the programme for Manchester is due to follow within a year or two after the first three exchanges have been opened. During this second stage of the operations about 20 additional automatic exchanges will be provided, including the first 10,000 line unit (Blackfriars) at Chapel Street, and the exchanges in the area at which manual working is to be continued for a time are, with a few exceptions, to be equipped with call indicator positions on which all calls from automatic subscribers will be displayed. Tandem switches will be installed in the Blackfriars exchange to deal with traffic for which direct junctions between the exchanges concerned would not be justified. Although the bulk of the manual traffic complementary to the automatic system will be concentrated at Chapel Street, two subsidiary auto-manual boards will be established in the Manchester area, one at Oldham, and the other at Ashton-under-Lyne, as an economy in line plant costs will result from dealing with a part of the Toll and enquiry traffic at those places.

The existing Manchester Trunk Exchange will be maintained and will provide communication with places outside the range of the Toll area. In order that the transmission on these long distance calls may be as efficient as possible, direct dialling-in circuits will be provided from the trunk exchange to all automatic exchanges in the Manchester area.

The Stockport automatic exchange, where the present equipment is of non-director type, will be converted to Director working.

Replacement of remaining Manual Exchanges.—The final phase of the scheme will be the transfer to automatic working of the remaining thirteen manual exchanges, one by one, as each becomes due for replacement. These exchanges are equipped with up-to-date manual plant which will give good service for several years.

Exchange Codes.—A primary consideration in any Director area is the choice of suitable names for the exchanges, and in this connection the question arises as to whether it would be possible in the case of Manchester to use two letters only for the exchange codes. The grouping of letters and figures on the dial plate is given below for reference:—

1	2	3	4	5	6	7	8	9	0
—	ABC	DEF	GHI	JKL	MN	PRS	TUV	WXY	O

Since " O " is to be used as a single digit for enquiry calls, only the 8 dial spaces 2 to 9 are available for the first code letter for other calls. For the second code letter, the 9 dial spaces 2 to 0 may be used, so that 72 numerical combinations would theoretically be available for a series of two-letter codes. Some reduction in this number is necessary, however, owing to the fact that the digits 5, 6, 7 and 9 correspond to groups of consonants only, and the choice of suitable exchange names beginning with an available combination of two consonants in these groups would be very restricted. Assuming, for example, that no combination of these digits alone could be usefully employed, the total number of available combinations is reduced by 16, *i.e.*, to 56. Now already 41 codes will be required in Manchester (including those for Trunks, Toll, Directory and Telegrams) and some allowance must be made for the additional exchanges and services which will doubtless be necessary as the scheme develops. Also, under a two-letter code scheme, some of the existing exchange names would have to be changed. For example, only one of the names CHeetham Hill, CHorlton and CIty could be used. It will be seen, therefore, that it would hardly be practicable to use a two-letter code in Manchester, and the Post Office Administration have decided to make the three-letter code standard for all Director areas in this country.

Since " O " is used for enquiries, and therefore cannot be used as the first letter of an exchange code, the exchanges at Oldham and Openshaw will be known under the automatic scheme as " Main " and " East " respectively.

Grouping of Directors.—It will be recollected that when one of the three-letter codes in a Director system is dialled, the first digit steps up the " A " digit switch to one of the levels 2—9. The " BC " digit switches are thus divided into eight distinct groups, but if in two or more of these groups, the " BC " digits have all a different numerical significance, they could clearly be combined by " commoning " the " A " digit levels concerned. In the Manchester area, it has been found possible by a suitable choice of the new exchange names so far required to reduce the number of groups of Directors (" BC " switches) to three, as tabulated below, and illustrated in Fig. **5**.

GROUPING OF " A " DIGIT LEVELS IN THE MANCHESTER AREA.

Level 2.		Levels 3, 8, 9.		Levels 4, 5, 6, 7.	
NAME.	Numerical equivalent.	NAME.	Numerical equivalent.	NAME.	Numerical equivalent.
ARDwick	273	DEAnsgate	332	GATley	428
ASHton	274	DENton	336	HEAtonmoor	432
BLAckfriars	252	DIDsbury	343	HYDe	493
BROughton	270	DIRectory	347		
CHEetham	243	DROylsden	370		
CENtral	236	EASt	327	LONgford	506
CHOrlton	240	ECCles	322		
CITy	248	FAIlsworth	324	MOSs Side	607
COLlyhurst	205			MAIn (Oldham)	624
				MIDleton	643
		TRAfford Park	872	MEDlock	633
		URMston	876		
		VICtoria	842	PENdleton	736
		TRUnks	878	PREstwich	773
		TELegrams	835	RADcliffe	723
		TOLl	805	RUSholme	787
				SALe	725
		WALkden	925	STOckport	780
		WHItefield	944	SWInton	794
		WOOdley	900		

The effect of this grouping will be a reduction in the number of Directors required at the various exchanges of from 15 to 20 per cent.

Reference has already been made to the use of " O " for obtaining the assistance of a telephonist. When an ordinary, *i.e.*, non-coin box subscriber dials " O " he will obtain an outlet on level " O " of the " A " digit switches to a Director switch which has been arranged so as to route the call at once to the Monitors desk. At the Ardwick, Collyhurst and Moss Side Exchanges, the Directors in the last group (levels 4, 5, 6 and 7) will be equipped for " O " level service and the " O " level will be included in the group. The circuit conditions demand that the positive and negative wires in the strapping from level " O " shall be reversed.

The arrangements for dealing with coin box calls on level " O " are referred to later.

Satellite Working.—The discriminating equipment designed for use at Satellite exchanges in Director areas provides for the division of originating traffic into the following groups:—

(*a*) Calls for local subscribers.
(*b*) Calls to be routed *via* the parent exchange.
(*c*) Toll calls.
(*d*) Calls for one or more nearby exchanges.

These facilities will, it is anticipated, render it economical to work a number of exchanges in the Manchester area as satellites. On the basis of the data at present available, the grouping of these exchanges will be as shown below, although it should be mentioned that this scheme may be somewhat modified later, as the forecast of future development in portions of the area is under review.

Parent Exchange.	Satellite Exchanges.
Blackfriars ...	Cheetham Hill, Eccles, Failsworth, Broughton, Middleton, East, Pendleton, Prestwich, Radcliffe, Swinton, Walkden, Whitefield.
Ardwick	Denton, Droylsden, Gatley, Heaton Moor, Hyde.
Trafford Park ...	Chorlton, Longford, Sale, Urmston.
Stockport... ...	Woodley.

Fig. 2 illustrates the facilities provided by the discriminating selector repeater equipment for satellite exchanges in a Director area. In the case shown (Swinton), the coin box lines are to be worked on a simple satellite basis, discriminating equipment being provided for ordinary—*i.e.*, non-coin box—traffic only. For local calls, the code SWI is "absorbed," and the discriminating selector then functions as a first numerical selector, level 1 being connected to second selectors serving the group of numbers 1000-1999. For calls to Eccles, Toll and Pendleton, the levels brought into use correspond to the third code or " C " digits, *i.e.*, C, L and N, respectively. The spare discriminating selector levels are available, of course, for additional direct routes, or an extension of the local numbering scheme, if required.

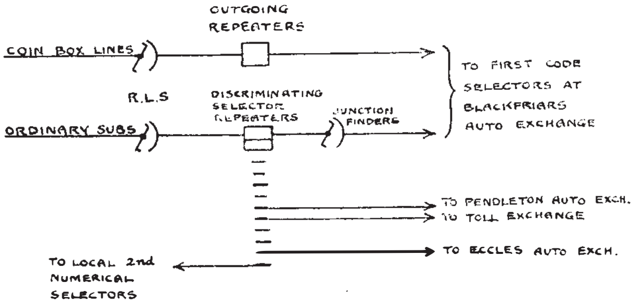


FIGURE 2 TYPICAL TRUNKING ARRANGEMENTS AT A SATELLITE EXCHANGE (SWINTON) [OUTGOING ROUTES ONLY]

Coin Box Traffic.—The coin collecting boxes used in Manchester will be of the prepayment multi-coin type now adopted as standard for automatic areas. To make an automatic call the caller at a coin box telephone, after inserting the 2d. fee, will dial the exchange code and number of the wanted subscriber, and the call will then be routed in the same way as a call from an ordinary subscriber. For other calls, the coin box user will dial "O," and such a call will appear on distinctively labelled calling equipment on the manual board, thus notifying the operator that the call is made from a coin box telephone, in order that the proper fee may be collected. The segregation of this class of coin-box traffic from that originated by ordinary subscribers necessitates the provision, for coin box lines, of a separate group of first code

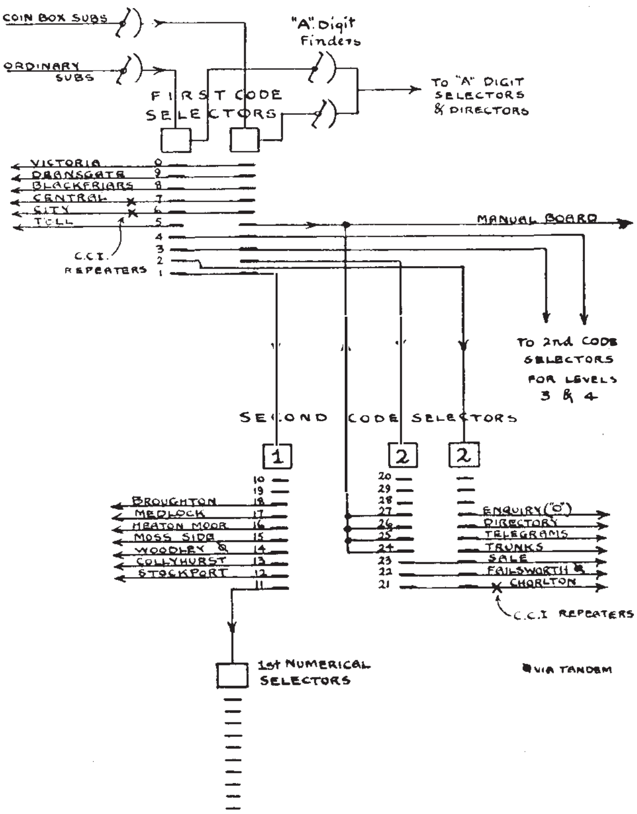


FIGURE 3. EXTRACT FROM TRUNKING DIAGRAM FOR ARDWICK EXCHANGE, SHEWING THE ROUTING OF COIN BOX CALLS.

selectors, and a separate group of second code selectors on the level used for manual board services, as illustrated in Fig. **3**, which is perhaps self-explanatory. It will be seen that provision will be made for the possibility of a coin-box caller inserting 2d. and dialling TOL, TRU, TEL or DIR, although this would be an incorrect procedure on his part.

Junction Fee Calls.—As the Manchester telephone area will extend to a distance of 7 miles from the centre of the City, junction fees will be payable on calls between certain exchanges in the area. These calls must therefore be routed to the auto-manual board, where they will be recorded and completed by an operator. In the case of an exchange which is the parent for a number of satellite exchanges at various distances from the centre of the area, the question arises of providing, at the parent exchange, some means of effecting the necessary discrimination between one satellite exchange and another in regard to the routing of these calls. A method devised by the Department's engineers is illustrated in Fig. **4**. It involves the provision of separate groups of 2nd code selectors, and a special scheme of level allotments to suit the particular case. The diagram shows the arrangements at Ardwick exchange in connection with the 2nd code selectors on level 4 only, those relating to levels 1, 2 and 3 being omitted for the sake of clearness.

As an example of the operation of the scheme, consider two calls to Longford, the first from Droylsden, and the second from Denton. In each case the exchange code LON will be translated in the common group of Directors at Ardwick into the digits 47. The call from Droylsden, however, will be routed direct from the second code level at Ardwick to a first numerical selector at Longford, whereas that from Denton will be sent *via* one of the special group of junctions to the manual board at Chapel Street.

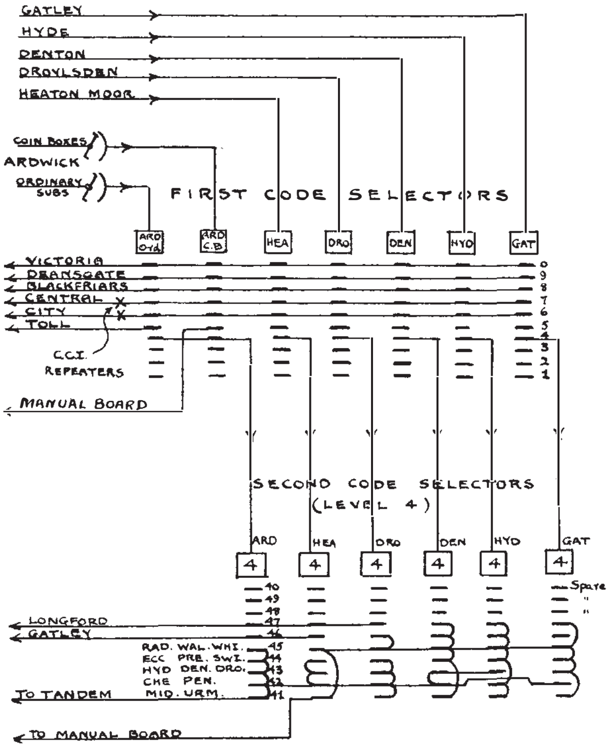


FIGURE 4. ARDWICK AUTOMATIC EXCHANGE. EXTRACT FROM TRUNKING DIAGRAM TO ILLUSTRATE ARRANGEMENTS FOR ROUTING EXCESS FEE CALLS TO MANUAL BOARD

Taking another example, a call from Droylsden, to Prestwich will be routed from Ardwick *via* Tandem as a unit-fee call, with the translation 448 (the digit 8 taking effect at Tandem, where Prestwich will be served from a first tandem level), while a similar call from Denton will reach the manual board (the digit 8 in this case being ineffective) as in the previous example.

Blackfriars Exchange.—As already indicated, Blackfriars will be the parent exchange for a number of satellite exchanges, and will also contain tandem switches for cross-area traffic. A considerable amount of equipment will therefore be required for this installation, as will be seen from the following summary of the main items :—

For Traffic from :—	Subs. Pre-selectors.	Code or Tandem Selectors.		Numerical Selectors.		
		1st	2nd	1st	2nd	Final
Blackfriars Subs.	9440	1580	2000	220	1640	2608
Satellite Exchanges	—	1180				
Auto Exchange and Tandem Groups...	—	380	2060	1040		
Key Sender Positions	—	1520	340	—		
Other Manual Board Positions ...	—	—	—	200		
Dialling-in Exchanges	—	—	—	280		
Total	9440	4660	4400	1740	1640	2608

" A " Digit Switches	300
Directors	400
Senders	50

Fig. **5** shows in outline a portion of the proposed grouping arrangements for the Blackfriars, Tandem and Auto-Manual switches at Chapel Street. The code, tandem and numerical switches shown in the diagram will all be equipped with 20-contact levels. With the exception of the 1st code levels 1 and 0, the proposed allotment of levels has been omitted from the diagram. The first code levels 6 to 9 will carry traffic to the Central, City, Deansgate and Medlock exchanges respectively; the remaining exchanges will be reached *via* second code selectors on levels 1 to 5, and the second code switches on similar levels at Deansgate and Victoria (the other two exchanges which are to be installed in the same building) will eventually be ranked up with those for the Blackfriars equipment, so as to facilitate the grouping of outgoing junctions.

It will be observed that switches in connection with key sender positions are associated both with first code and first numerical selectors, the former being outlets for the 7-digit positions and the latter for the 4-digit positions. Experimental development is at present in progress with the object of making provision for key-sending direct from " A " positions at manual exchanges to automatic exchanges. An article on this subject, by Mr. J. Hedley, was published in the Journal for April, 1926 (pp. 18 to 21). Where this method of working can be adopted key-sending " B " positions at the auto-manual boards will not be necessary.

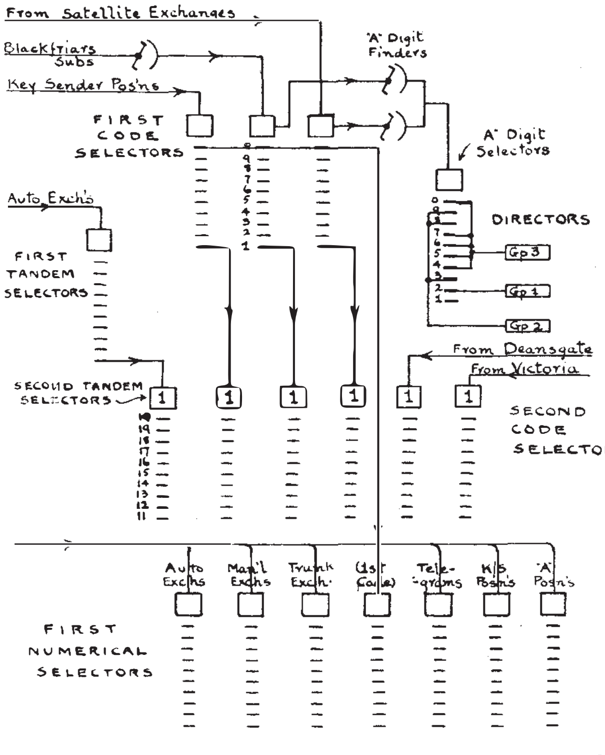


FIGURE 5 BLACKFRIARS AUTO EXCHANGE.
EXTRACT FROM TRUNKING SCHEME

SUBSCRIBERS' APPARATUS IN AUTOMATIC AREAS.

H. G. S. PECK, B.Sc. (Hons.), M.I.E.E.

PART II. EXTENSION ARRANGEMENTS.

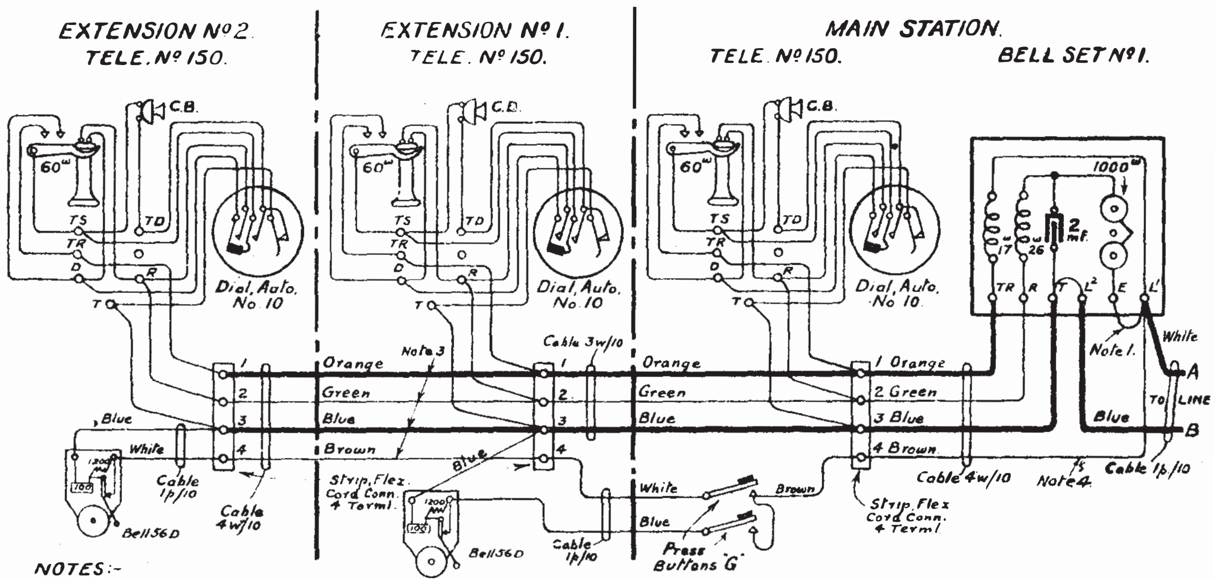
A NUMBER of combinations of telephones and bells have been standardised to meet the needs of subscribers who rent a few extensions only and do not in general require intercommunication between them. These combinations are known to both the commercial and engineering staffs as "Plans," and have been given a series of numbers which refer to the arrangements and not to the type of telephone, which is specified separately for each station.

To avoid an undue increase in the number of through switching points, the arrangements that may be fitted on extensions from branch exchange switchboards are limited to those that do not involve any further switching through of a connection, and it may be noted that dials are not fitted on manual private exchange extensions in automatic areas unless direct night service is required. External lines are only provided when not more than two wires are required for each circuit.

The station at which an incoming ring is received when all switches and keys are normal is known as the main station, the others being extension stations. A magneto extension bell can be added in any case where it is desired at any time that an incoming ring should be heard at a point remote from the main station.

Wherever possible, a parallel arrangement of telephones has been adopted, using a common induction coil and connected so that the operation of the dial at any one station does not tinkle the bell at another. When secrecy is required, a switch is fitted to disconnect the unwanted telephone at will, and where intercommunication is to be available, generators and other additional apparatus are necessary.

A typical detailed diagram of an installation of parallel telephones is shown in Fig. 6. This particular arrangement is known as Plan 1, and if the wiring to the extension and to the press button be omitted the connections of the main station are those of a simple direct exchange line.



NOTES:-

1. Omit strap and connect extension bell when required.
2. Extensions from Manual P.B.X. Equipment will be connected as for C.B. working if night service is not required.
3. These connections may, if more convenient, be made at the main station and 4 wire cable used for both extensions.
4. Connect this wire to earth when connection to L1 gives insufficient current to actuate bell.

FIG. 6.—MAIN SET AND 2 EXTENSIONS.

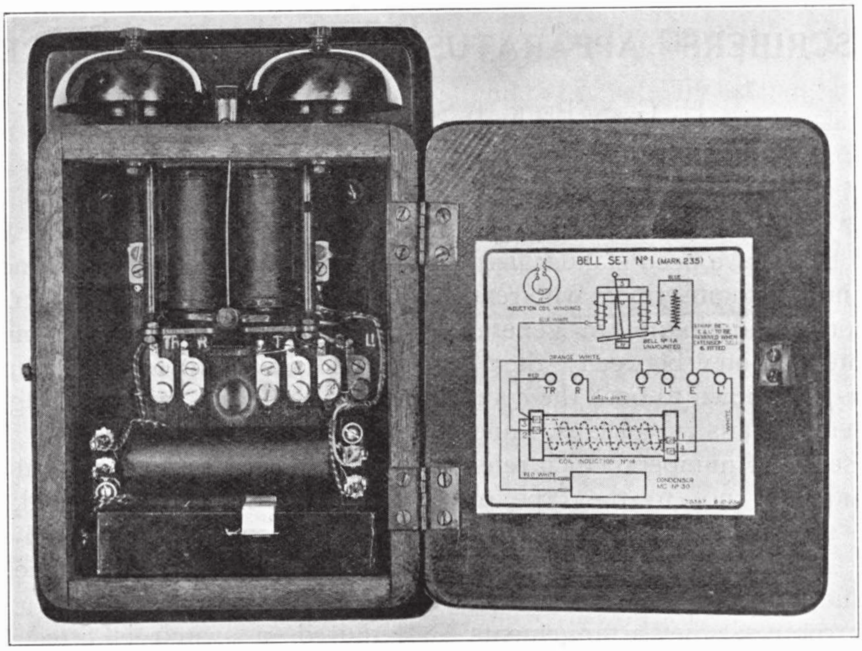


FIG. 7.—BELL SET NO. 1, SHOWING INTERIOR.

Table telephones are shown in this diagram and the common induction coil, condenser and bell are included in one case known as a "Bell Set No. 1" and illustrated in Fig. **7**. The transmitter, receiver, bell, switch-hook and cord are known as a "Telephone No. 150" and this is illustrated in Fig. **8**. Back and front views of the dial, showing the number ring and label used in Director areas are shown in Fig. **9**. A wall telephone is shown in Fig. **10**.

It will be seen that the connections of all the telephones in Fig. **6** are the same, and that the removal of any receiver from its hook loops the line and establishes the condition illustrated in Fig. **3** of Part I. of this article. No tinkling of the bell occurs whichever dial is used, a condition which is of particular importance with such arrangements, as should tinkling occur and be mistaken by the main station for a calling signal, the removal of the receiver to answer the call there might mutilate the train of impulses being dialled from an extension.

A simple parallel arrangement such as this has its chief application when several telephones in one room are to be connected to one line, a local bell circuit then being unnecessary. The arrangement can also be used when the telephones are in separate rooms and the local call bells shown are then required. These bells

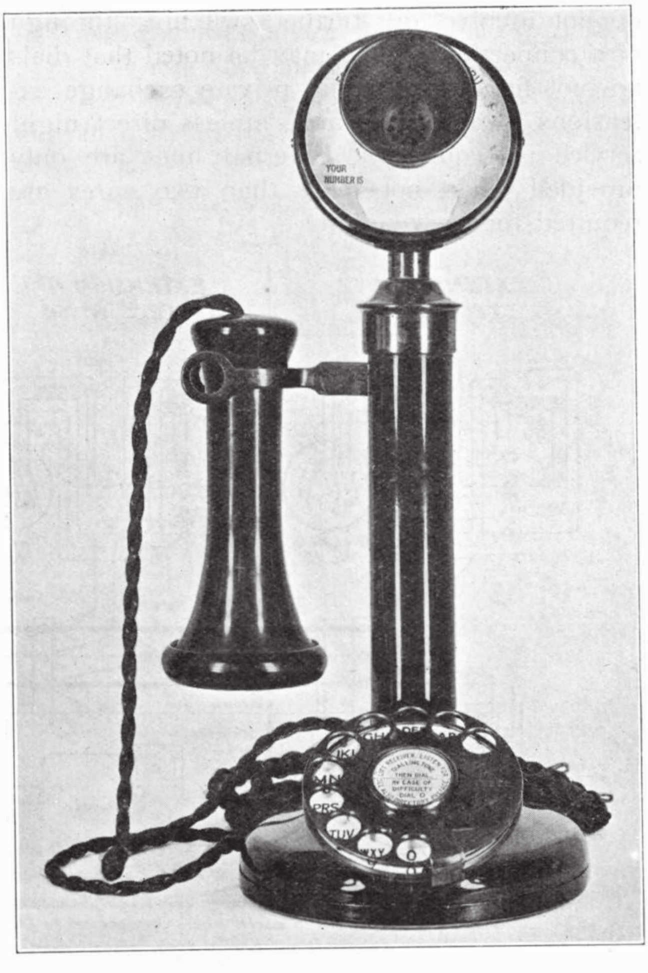


FIG. 8.—TELEPHONE NO. 150. STANDARD TABLE TELEPHONE.

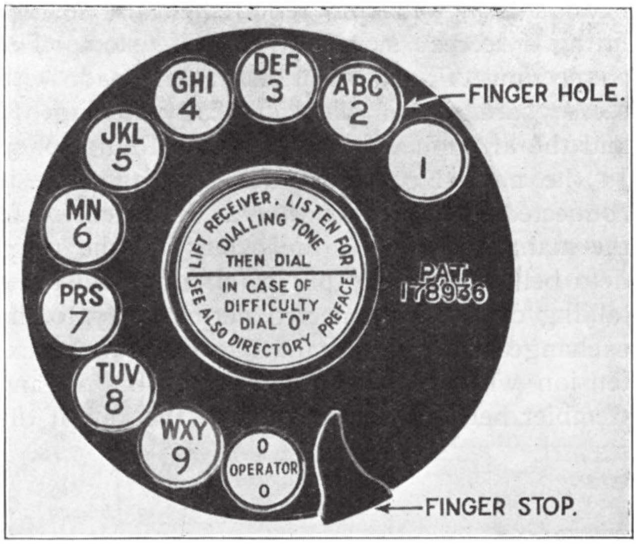


FIG. 9.—DIAL FOR MULTI-OFFICE AREAS. FRONT VIEW.

are rung by current drawn from the line and are usually connected across the loop, so avoiding the need for earth connections which, however, become necessary when the line resistance is excessive. It was found that when an ordinary trembling bell connected in this manner was rung for the purpose of extending an incoming call the noise created in the receiver at the distant end of the line was objectionably violent. To avoid this the break contacts of the bell have been bridged by a non-inductive resistance. The best value for this purpose was found to be 1,200 ohms; too low a resistance would retain the bell armature in the operated position and a high resistance would not sufficiently reduce the noise. A bell of this type in which the resistance bobbin is included is shown in Fig. **11**. As a matter of policy, the number of instruments that may be connected in parallel in this way is limited to three on business lines and to six on residential lines.

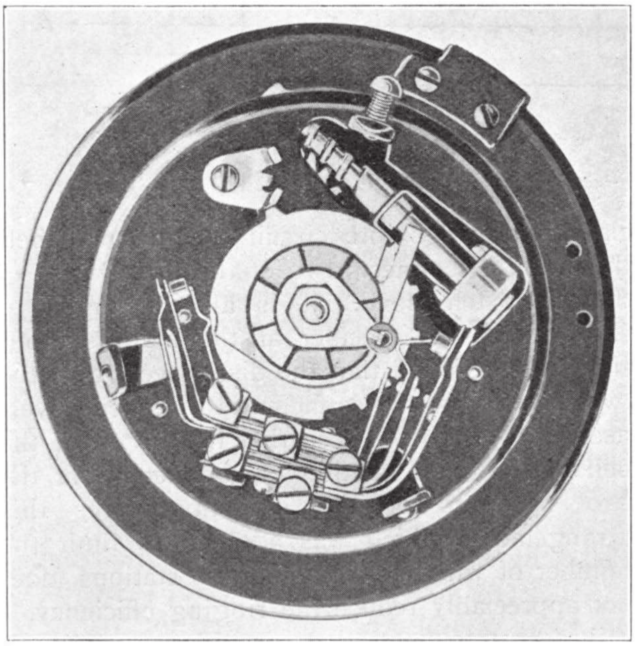


FIG. 9*a*.—DIAL FOR MULTI-OFFICE AREAS. BACK VIEW.

The conditions when a busy or important person wishes his incoming calls to be filtered by a secretary after having been answered in an outer office are met by connecting the local bell circuits in tandem, that is to say, the bell at the first extension is actuated by the press button at the main and the bell at the second extension can only be actuated by press button from the first. Such an arrangement is known as Plan No. 11.

FIG. **10**.—WALL TELEPHONE. MULTI-OFFICE AREAS.

When two telephones (the main station and one extension) are required on one line and it is desired that incoming rings shall be received at the extension when the main station is unattended, a magneto bell with a short-circuiting switch is fitted at the extension and connected in series with the bell at the main station. The telephones are connected in parallel and a local bell circuit is not included. The arrangement is known as Plan No. 1A.

An arrangement of two exchange lines with one extension that can be connected in parallel with the terminal telephone of either line is known as Plan No. 8. Each main station has a press button connected to a bell of distinctive tone at the extension and a key is provided at the extension for transferring the telephone from one line to the other as desired.

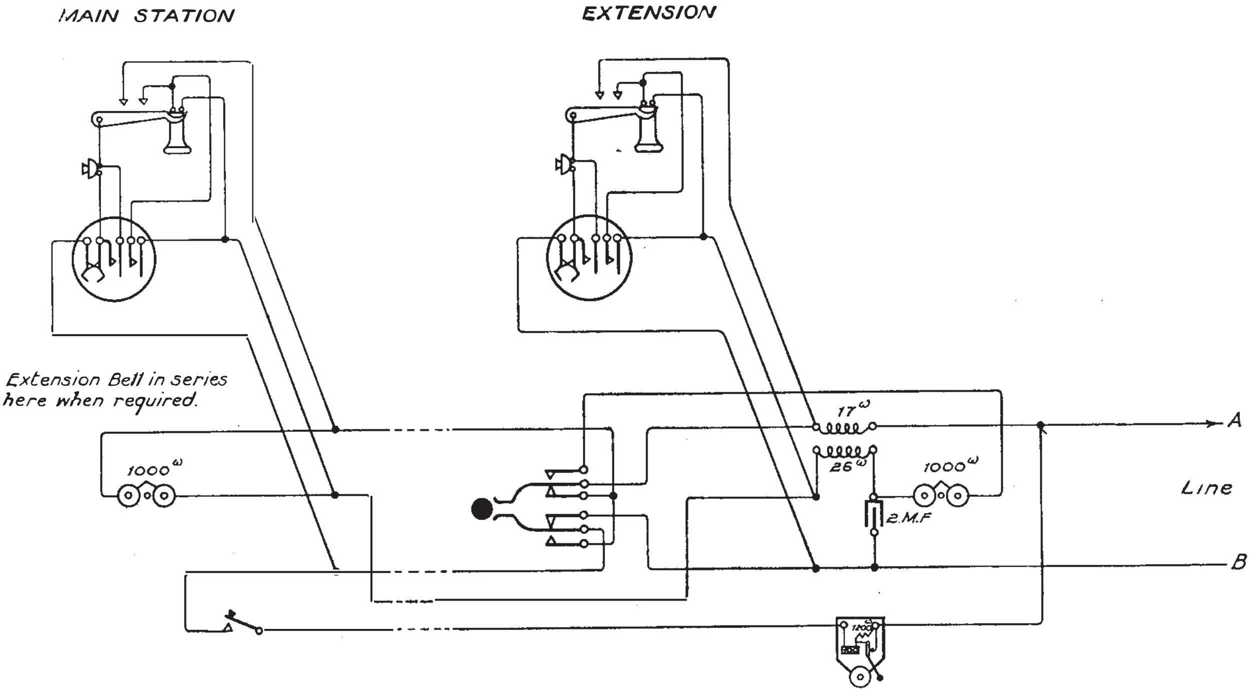


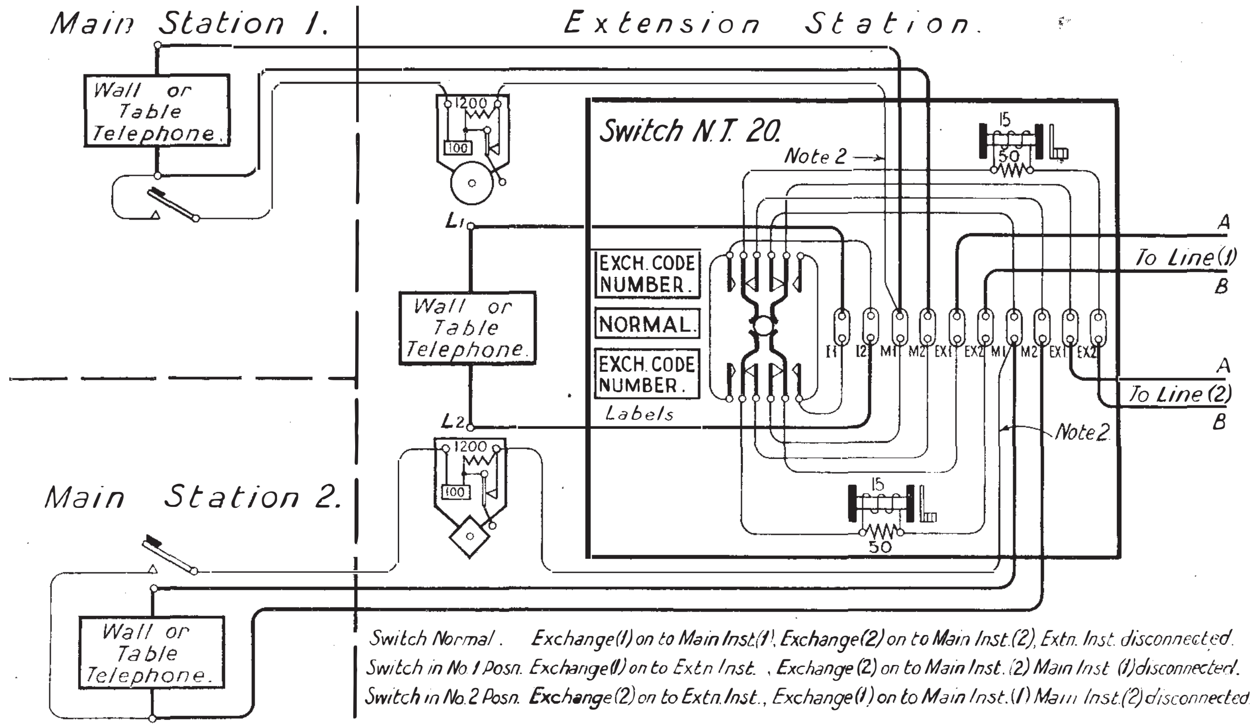
Fig. 11.—Main Station with one Extension having Secrecy against the Main.

Parallel arrangements of telephones such as already described do not provide secrecy, since it is possible for a conversation carried on from any telephone to be overheard on any other telephone on the same line, nor are they suitable for use when intercommunication between one telephone and another is required, since the line relay at the exchange is actuated by the removal of the receiver from the hook at any telephone.

It is often necessary in business that a manager or other important member of the staff on an extension telephone shall be able to carry on a conversation that is secret as regards the main station and this requirement is met by fitting a secrecy switch at the extension. The connections of a main station and extension with secrecy are shown diagramatically in Fig. **11** and the arrangement is known as Plan No. 3. In the normal condition the exchange line is connected through the switch at the extension to the main station. At the extension, the magneto bell is normally out of circuit, whilst the talking circuit is connected permanently to the exchange line. The main station calls the extension when required by a press button and trembler bell. The operation of the key at the extension brings into circuit the magneto bell there and disconnects two of the three wires to the main telephone. It is also arranged to short-circuit the receiver at the main station, since it was found that the disconnection of the two wires was not sufficient to prevent overhearing. It will be seen that the circuit of the bell at the main station is completed *via* the two windings of the induction coil; this arrangement, which was adopted to limit the number of wires between the two stations, does not appreciably reduce the ringing efficiency.

An arrangement that provides a common

extension on two exchange lines, with secrecy is known as Plan No. 8A and is shown in Fig. **12.** Each exchange line is connected to a separate main telephone *via* a combined switch and signal at the extension point. The movement of the switch in either direction disconnects one of the exchange lines from its main station and connects it to the extension telephone. A signal is provided in series with each line at the extension station to avoid interruption by the operation of the switch when a line is engaged. The bell at the extension station is in circuit when the receiver is on the rest, and if the key be left in the operated position any incoming ring is received at the extension station. In the normal condition all incoming rings are received at the main stations, and, to enable the extension to be signalled when required, press buttons are fitted at the main stations and connected to trembler bells of different tones at the extension.



Switch Normal. Exchange (1) on to Main Inst. (1), Exchange (2) on to Main Inst. (2), Extn. Inst. disconnected.
Switch in No. 1 Posn. Exchange (1) on to Extn Inst., Exchange (2) on to Main Inst. (2) Main Inst (1) disconnected.
Switch in No. 2 Posn. Exchange (2) on to Extn. Inst., Exchange (1) on to Main Inst. (1) Main Inst. (2) disconnected

Notes:- (1) When an Extension Bell is required at any of the Stations, it will be connected in series with the Normal Bell.
(2) Connect this wire to Earth, when connection to M1 gives insufficient current to actuate Bell.

FIG. **12.**—TWO LINES AND COMMON EXTENSION WITH SECRECY.

When an extension with both intercommunication and secrecy is required, more complicated switching and signalling apparatus must be installed. This comprises a generator, magneto bell, indicator-relay, condensers and a four position switch, which are mounted together in one case as shown in Figs. **13** and **14** and are known as a " Bell Set No. 20."

Signalling between the main station and the extension is by hand generator in both directions and four positions of the switch give the following conditions:—

(1) Exchange line connected to telephone. Extension connected to bell in bell set.
(2) Exchange line connected to bell in bell set. Extension connected to telephone.
(3) Lines connected as in position (2), but the exchange connection is " held."
(4) Exchange line connected through to extension.

The connections of the arrangement are shown in Fig. **15.** With the switch in the first position all springs are normal and the indicator-

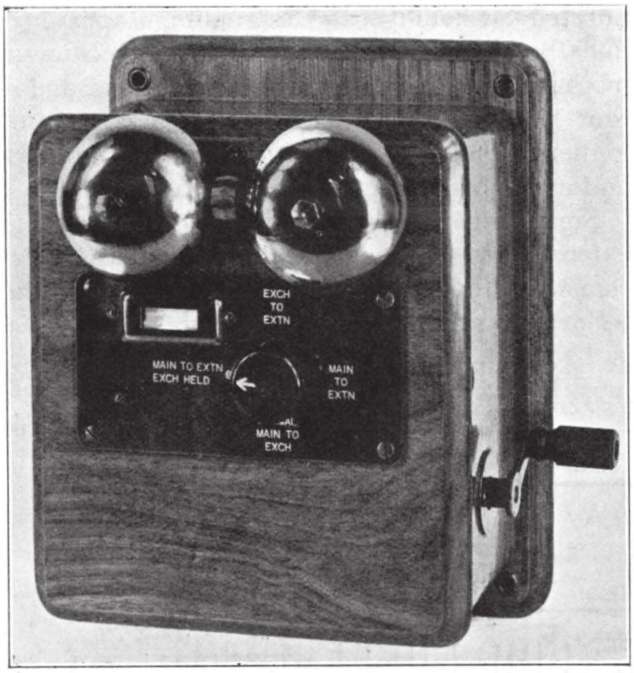


Fig. 13.—Bell Set No. 20.

relay is out of circuit. In the second position, spring sets Nos. 2 and 3 are operated, the indicator-relay still being out of circuit, but two cells for local talking are connected in series between the main station and the extension. In the third position, spring set No. 1 is operated also; this short-circuits the one microfarad condenser and half the bell coils, thus bridging the exchange line by a 500 ohm loop consisting of the other half of the bell coils, so providing a means for holding an exchange connection whilst a " secret " conversation is being carried on between the main and the extension. In the fourth position spring set No. 4 only is operated; the indicator-relay is in series with the extension and, if terminals A and A1 and B and B1 have been strapped as shown in the figure, the main telephone is in parallel with the exchange line. Conversations between the extension and the exchange are not then secret and the arrangement is known as Plan No. 7. If these terminals are not strapped, such conversations are secret and the arrangement is known as Plan No. 7A.

The bell of the telephone at the main station is disconnected by springs on the key when in the through (fourth) position and the bell of the bell set is disconnected by the action of the indicator-relay. All bridges are thus removed from the circuit when a conversation is in progress between the exchange and the extension and the condenser shunt across the winding of the series relay is increased by its own action to 3 microfarads. The transmission losses have thus been reduced to a minimum as indicated by the following:—

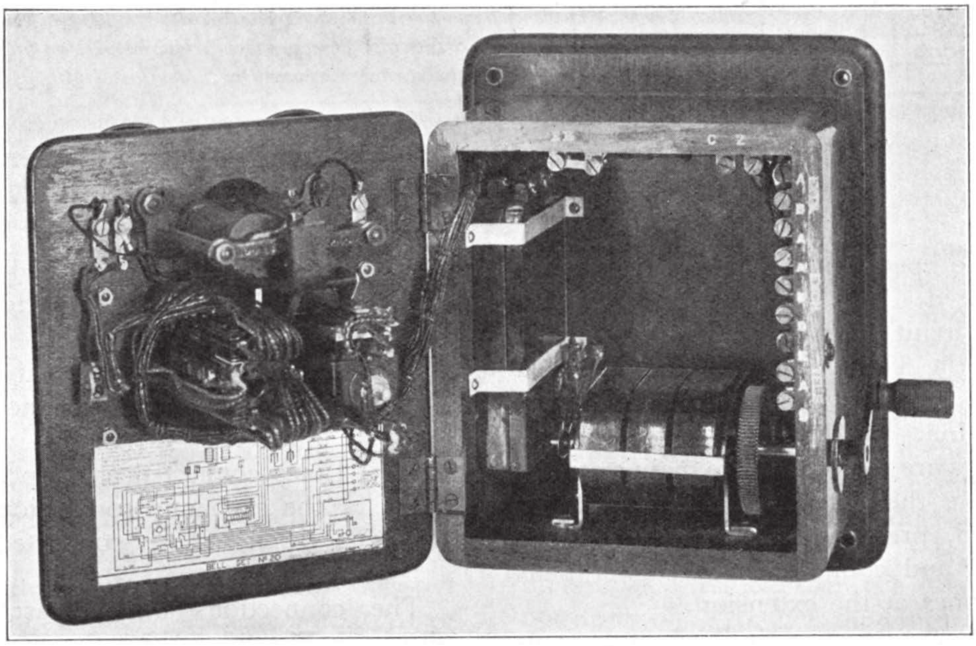
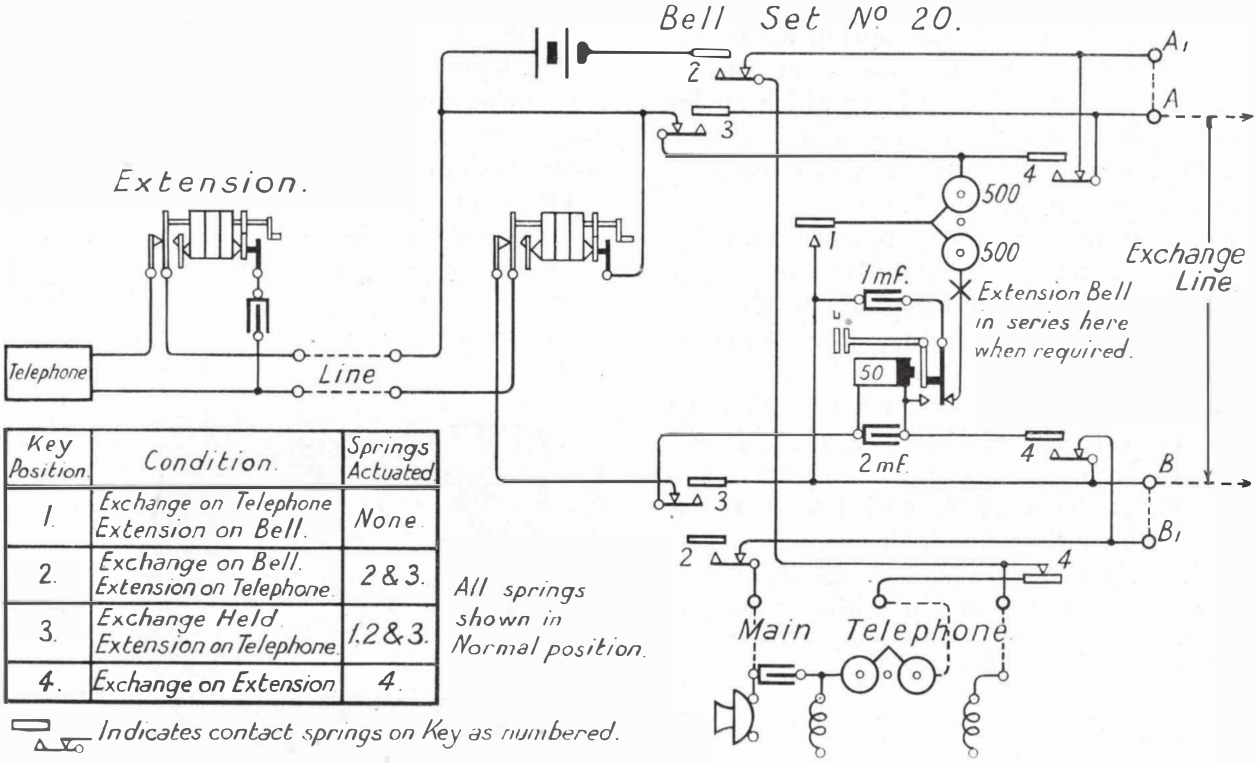


Fig. 14.—Bell Set No. 20, showing interior.


Bell Set Nº 20.
Extension.
Telephone
Line
A₁
A
B
B₁
Exchange Line
500
500
1mF.
50
2mF.
1
2
3
4
Extension Bell in series here when required.
Main Telephone
All springs shown in Normal position.
Indicates contact springs on Key as numbered.

Key Position	Condition	Springs Actuated
1.	Exchange on Telephone Extension on Bell.	None.
2.	Exchange on Bell. Extension on Telephone.	2 & 3.
3.	Exchange Held Extension on Telephone.	1.2 & 3.
4.	Exchange on Extension	4.

FIG. 15.—CONNECTIONS OF BELL SET NO. 20.

Sending loss 0.8 miles standard cable.
Receiving loss 0.4 ,, ,, ,,

The former figure includes the loss due to the reduction in the transmitter current by the introduction of the 50 ohms series resistance.

The indicator-relay, a side view of which is shown separately in Fig. 16, consists of a 50 ohm relay of the pendant armature type having

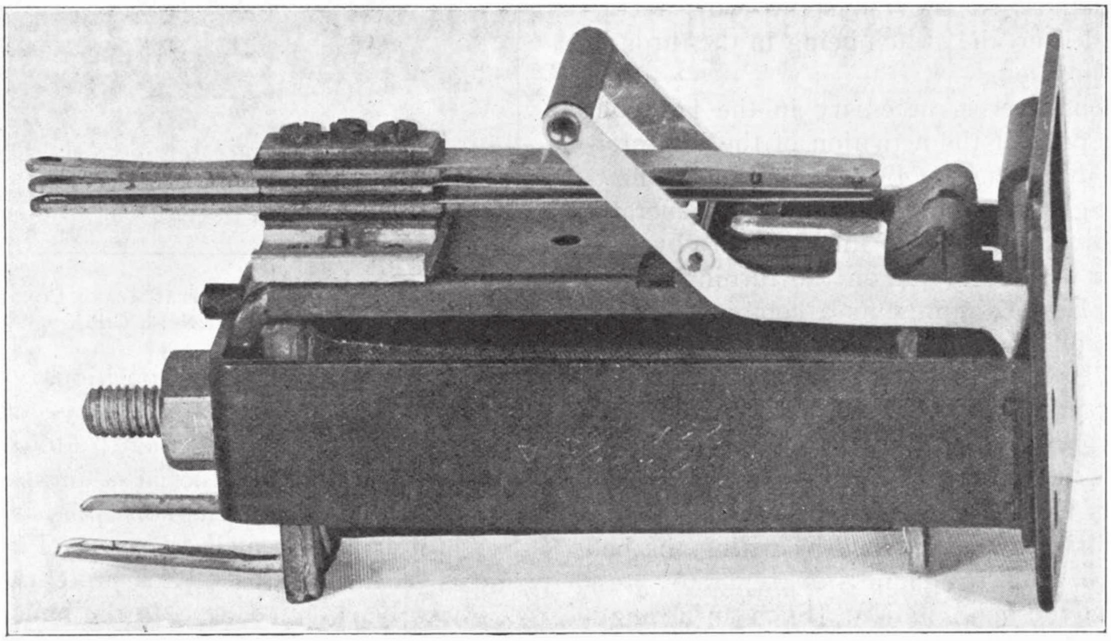


FIG. 16.—INDICATOR RELAY FITTED IN BELL SET NO. 20.

a copper sleeve on the core. The armature actuates a single change-over spring set of the usual type and an indicator attachment consisting of a balanced aluminium lever which moves an aluminium "flag" into position behind a rectangular window 1″ × 5/16″ when actuated.

The indicator-relay, which operates satisfactorily on lines up to 750 ohms resistance divided in any proportion between the exchange line and the extension, was designed by Messrs. Siemens Bros. & Co. to meet the following conditions:—

1. The relay contacts shall not break when an extension is being rung from the exchange on a zero line with maximum generator E.M.F. and lowest resistance ringing circuit in use.
2. The signal shall operate with the current over a maximum line with a minimum P.D. on the main exchange battery.
3. The relay having operated as in (2) shall retain during dialling at minimum speed, *i.e.*, the bell in the bell set shall not tinkle.
4. The relay shall release after operation as in (2) or (3) on a 10 ohm line and with maximum P.D. on the main exchange battery.
5. The relay contacts shall not break when the extension rings the main station by hand generator in series with a condenser, the switch being in the through position.

The condenser is necessary in the last condition to prevent the actuation of the indicator-relay by direct current from the exchange flowing through the winding of the hand generator when this is brought into circuit by the operation of the cut-out on the turning of the handle. Fig. **17** represents a combined generator and condenser which is known as Generator No. 4 C.P.

A second extension may be connected with its talking circuit in parallel with the first on a Bell Set No. 20 and the arrangement is then known as Plan No. 5 (or with secrecy No. 5A). Selective ringing is obtained by wiring the bell circuits of the telephones to separate press buttons at the main station. Such an arrangement avoids the necessity for fitting a branch exchange switchboard when one exchange line and two extensions are required, but intercommunication is limited to the extent that if one extension is talking on an exchange connection a simultaneous conversation cannot be carried on between the other extension and the main station.

On residential lines with only one telephone, the instrument has often to be moved as required from one part of the house to another, and this requirement is met by connecting the telephone to a plug and terminating the line on jacks fitted in convenient positions. The bell set is fitted near one of the jacks and all incoming rings are received there; additional bells can be fitted at any of the jacks and be brought into circuit when the telephone plug is inserted. Such an arrangement is known as Plan No. 4, and is particularly useful for professional men, one jack being fitted, say, in the hall, a second in the office or surgery and a third in the bedroom.

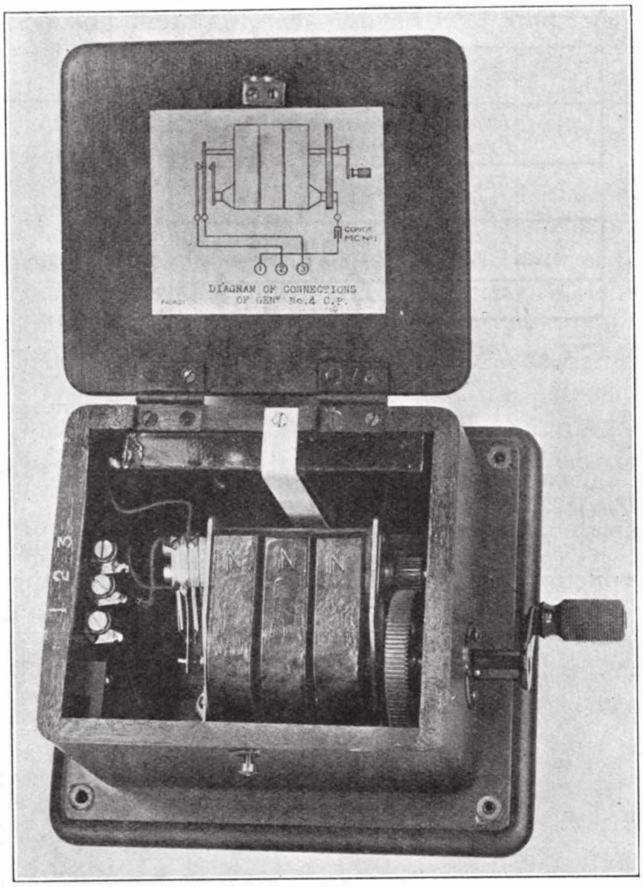
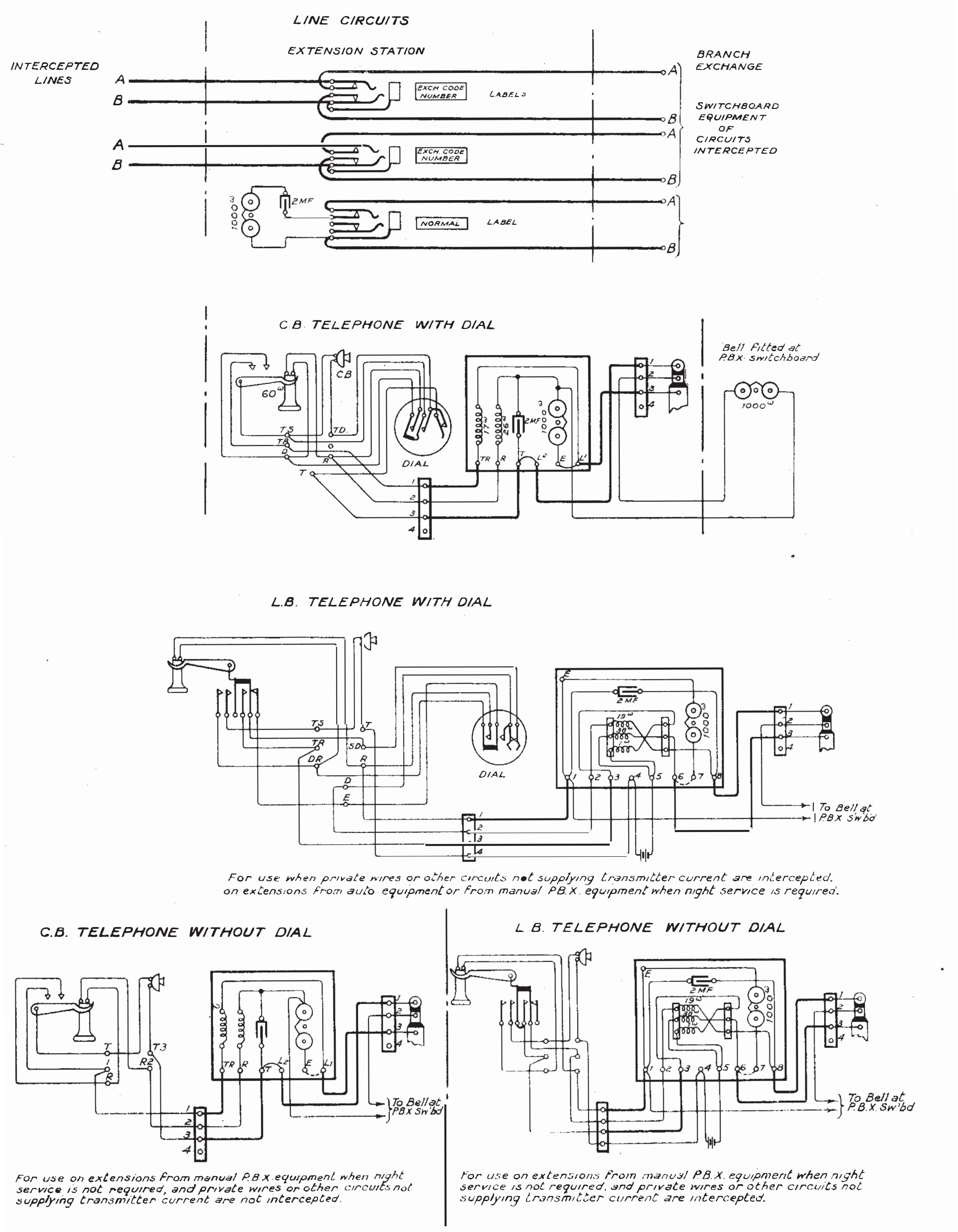


FIG. **17**.—COMBINED GENERATOR AND CONDENSER. "GENERATOR NO. 4 C.P."



For use when private wires or other circuits not supplying transmitter current are intercepted. on extensions from auto equipment or from manual P.B.X. equipment when night service is required.

For use on extensions from manual P.B.X. equipment when night service is not required, and private wires or other circuits not supplying transmitter current are not intercepted.

For use on extensions from manual P.B.X. equipment when night service is not required, and private wires or other circuits not supplying transmitter current are intercepted.

Fig. 18.—Branch Exchange Extension with Secrecy.

In addition to the foregoing there are two arrangements designed specially for use on extensions from private branch exchanges either manual or automatic.

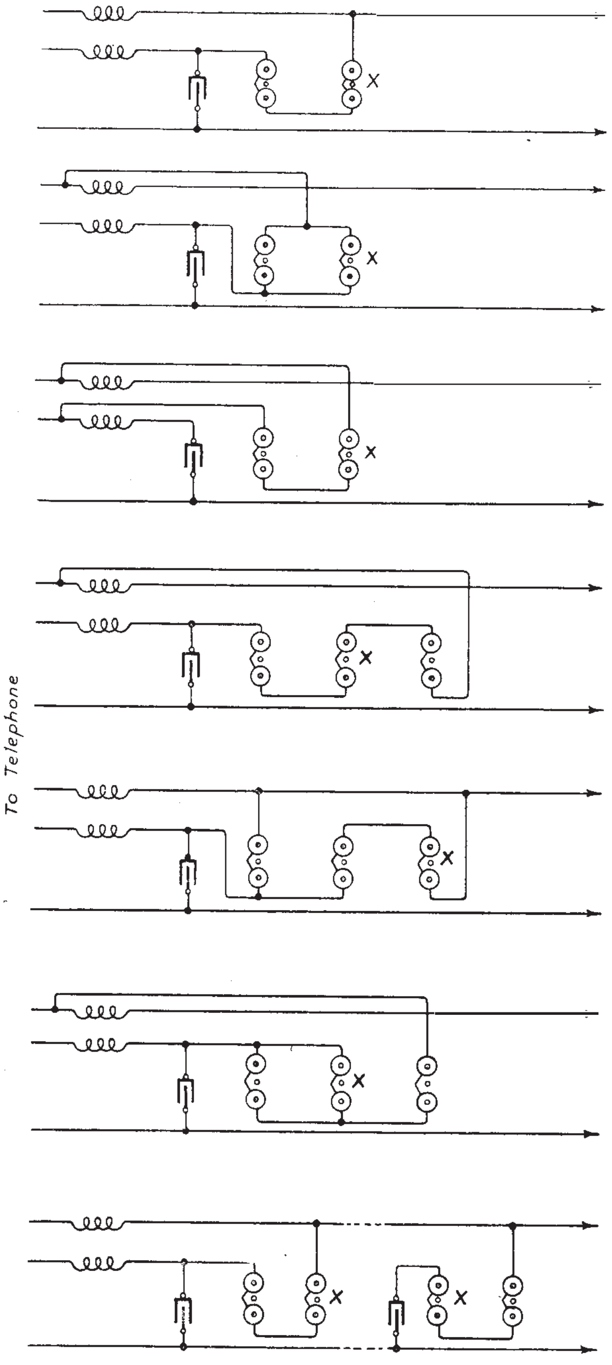
The first of these, known as Plan No. 9, includes a telephone and two lines from the branch exchange, one of which is used for all normal calls and is connected through a key to the telephone. Should it be desired to make an independent inquiry whilst a correspondent is waiting on the line, then the throwing of the key connects a holding loop across the first line and transfers the telephone to the second, which is reserved exclusively for originating such calls.

When extensions in accordance with this plan are connected to a private automatic branch exchange, they enable the fullest use to be made of the equipment, and facilities which are often obtained by the fitting of a separate house telephone system can be procured by the use of the one telephone fitted for the public service.

The last arrangement to be described is Plan No. 10, which is intended for use when secrecy against the private branch exchange operator is desired at an extension from a switchboard. The arrangement is shown in Fig. **18**, the particular connections of the plugs and jacks being adopted to avoid any liability to false impulses.

Except when a "secret" conversation is being carried on, the plug is kept in the jack marked "normal" and the extension line then terminates on the telephone in the usual way. All calls must be passed *via* the private branch exchange and the operator instructed when secrecy is desired; she will inform the extension user of the line on which the connection has been established, the telephone plug then being transferred to the corresponding jack. It is not intended that calls shall be originated by plugging immediately into an exchange line jack, as such a proceeding would lead to the interruption of other calls and to exchange lines being intercepted without the knowledge of the branch exchange operator. An extension bell is fitted in the switch-room to give an alarm should an incoming call mature on a line on which the telephone plug had inadvertently been left in the secrecy jack at the extension.

On occasion it is desired that private wires or other circuits not operated on a C.B. talking basis shall be intercepted in this way for the purposes of carrying on secret conversations and it then becomes necessary to fit a local battery telephone in place of the usual C.B. talking instrument. Also, whilst, as stated earlier, dials are not fitted on manual private



X *Indicates extension bell.*

FIG. **19**.—VARIOUS ARRANGEMENTS OF BELL CIRCUITS.

branch exchange extensions in automatic areas unless direct night service is required, they are required on all extensions from automatic equipment. The telephone circuits included in Fig. **18** are designed to meet these various conditions. Fig. **18** also serves to show the detailed connection of the local battery telephones referred to in Part I. and shown schematically in Fig. **5**.

In conclusion, it is interesting to collect in Fig. **19** the various arrangements of bell circuits to which economy in wiring has led. In each of these the item starred is the "extension bell" and may be a $2\frac{1}{2}''$ or $6''$ diameter magneto bell, a drop indicator giving a continuous alarm on a local bell circuit until the indicator is restored, or an A.C. relay giving a dis-continuous signal on a local bell in synchronism with the ringing from the Exchange.

AIDS TO THE STUDY OF IMPULSING IN AUTOMATIC TELEPHONE SYSTEMS.

By W. H. Grinsted and D. A. Christian.

As everyone concerned with automatic telephony knows, there are limits to the speed at which the selectors of a step-by-step system will operate reliably. A common requirement is that connections shall be correctly set up with impulsing speeds varying from 7 to 14 impulses per second, with certain specified line conditions. In applying this requirement it is necessary to consider the type of impulse, that is to say, the proportion of the total impulse period during which the circuit is open compared with that during which it is closed. This proportion can be expressed as the ratio of "break" to "make" or as the percentage of "break." For example, the dial standardised by the British Post Office delivers impulses at the rate or speed of 10 per second, having a ratio of break to make of 2 to 1 ($B : M = 2 : 1$), that is a mean percentage of break of $66.\dot{6}\%$.

Unfavourable line conditions, variations in the exchange battery voltage, incorrect relay adjustments, the presence of shunt circuits, and a number of other factors all affect the operation of the impulse relays and prevent the accurate repetition of the impulse delivered by the dial to the selector magnets. These factors introduce varying amounts of distortion, altering the ratio or percentage of break, as received at the switch being operated. Further, dials cannot be regarded as delivering perfectly uniform impulses of standard ratio at the standard speed. In commercial service all dials cannot be accurately adjusted to the ideal, and even if a dial be adjusted to give impulses having a speed of 10 per second and a mean percentage break of $66.\dot{6}\%$, the individual impulses of one train will depart somewhat from this standard.

It is therefore very important to consider how great the departures from standard conditions may be before the operation of setting up the number dialled becomes unreliable.

If the selectors are to perform accurately it is essential that their magnets should be energised and de-energised for certain minimum periods. This requirement fixes the higher limit to the speed of reliable operation. It is also essential that the period during which the release relay receives no current but holds by virtue of its slow releasing properties should not be too prolonged, and that the dialling relay which releases at the end of a train of impulses should receive sufficient energisation during the break period of the impulse to enable it to hold over the make period. These requirements fix the lower limits to the speed at which the system will accept impulses reliably.

It is clear that these limiting speeds are very considerably affected by the impulse ratio and therefore by the amount of distortion, and that the one factor (speed) cannot be considered without the other factor (ratio) and *vice versa*.

This interdependence makes it difficult to measure and state in a concise form the breakdown limits of any system or combination of circuits, and still more difficult to obtain any clear idea of the margin of safety between the performance which is to be guaranteed and that of which the system is capable.

There are broadly three divisions under which the question can be considered—(i) the nature of the impulses delivered by the dial, (ii) the nature of the most extreme impulses with which the system will operate, and (iii) the margin of safety existing between (i) and (ii). This is the margin which provides against loss of adjustment of dials, relays or switches, unfavourable line conditions, etc. We felt very early in the development of our automatic systems the need for some means of representing these three in such a way that the relation of one to the other could be readily grasped, and after some efforts in other directions we developed the method about to be described, which has been in use for the past twelve years in the laboratories of Messrs. Siemens Brothers & Co., Ltd., and has proved of great value.

This method enables one to read off at once the nature of an impulse either in terms of its speed and ratio or of its break and make periods. It gives a clear picture of the relation between the impulses delivered by the dial and the breakdown limits of the system, and of the margin of safety between these two.

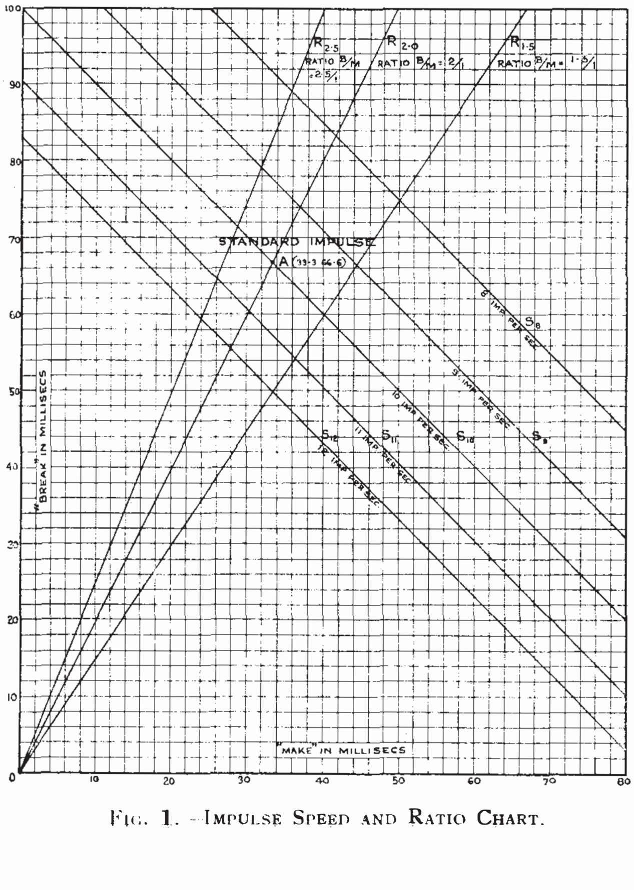


FIG. 1.—IMPULSE SPEED AND RATIO CHART.

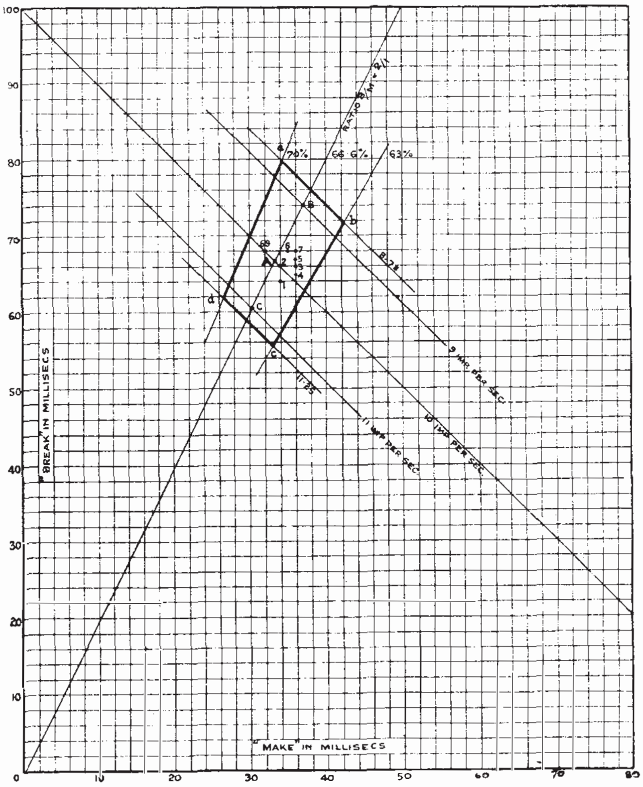


FIG. 2.—STANDARD DIAL TARGET.

It is necessary in the first place to regard impulses as defined not so much by speed and ratio, which are secondary or derived quantities, as by their more fundamental elements, namely, the absolute length of the make and break periods in milli-seconds. For example, standard impulses having a speed of 10 per second and a ratio of break to make of 2 to 1 are thus defined as impulses of $66.\dot{6}$ m.s. break and $33\cdot\dot{3}$ m.s. make. When impulses are measured in this way they can be plotted as points on squared paper, the abscissa representing the make period and the ordinate the break period. Thus in Fig **1**, point A ($33\cdot\dot{3}$, $66.\dot{6}$) represents the "standard impulse." Lines such as $R_{1.5}$, etc., for which B/M = a constant, are lines of equal ratios. For example, for all points on $R_{2.0}$ the ratio $B/M = 2$. Lines such as S_8, S_9, etc., for which $M + B$ = a constant, are lines of equal speeds. For example, for all points on S_{10} the sum of the make and break periods is 100 m.s. and the corresponding speed is 10 impulses per second. By plotting an impulse on a chart

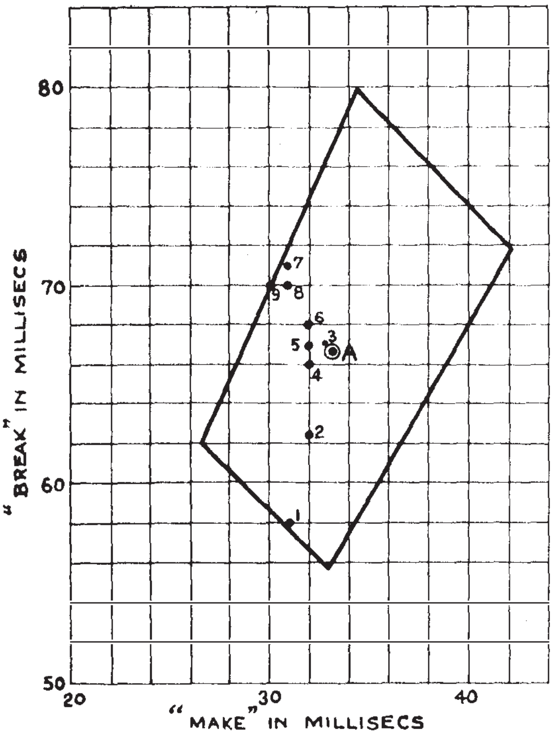


FIG. 3.—TARGET OF DIAL TENDING TO SLOW DOWN.

such as that in Fig. **1** therefore we have represented it completely.

Fig. **2** shows plotted in this way the train of impulses given by a standard Post Office dial when O is pulled.

Only nine points are shown, since when the contacts make after the tenth break the circuit is closed for an indefinite time. It is not possible, therefore, to measure the make period corresponding with the tenth break.

It will be realised that this group of points enables the ratio, the average speed and the degree of regularity of the impulses to be appreciated at once.

The limits allowed by the Post Office specification are shown by the quadrilateral *a b c d*. This is known as the "dial target." The specification calls for percentage break of 66.6% with tolerance limits of 63% to 70%. These limits to the ratio are represented by lines *bc* and *ad*. The dials are required to be adjusted so as to send not less than 9 nor more than 11 impulses per second. These are average or group speeds and, as pointed out above, a dial may send impulses at the desired rate and yet individual impulses of the train may differ from one another in their periods of make and break. The group speeds are represented by points B, C, but to make allowance for the variations of individual impulses the speed boundaries to the target, *i.e.*, the lines *ab*, *cd*, are taken as those corresponding with 8.75 and 11.25 impulses per second respectively. These figures are based upon the requirement originally proposed for the performance of the standard dial, namely, that no individual impulse should have a total length greater than that corresponding with a speed of 8.75 imp. per sec. or less than that corresponding with a speed of 11.25 imp. per sec.

The shape of the group of impulse points often reveals troubles due to the faulty design or construction of a dial; an example is given in Fig. **3**, which reproduces the target diagram for a dial which has a tendency to slow down.

Fig **4** shows target diagrams for a Post Office standard dial adjusted to (average or " group ")

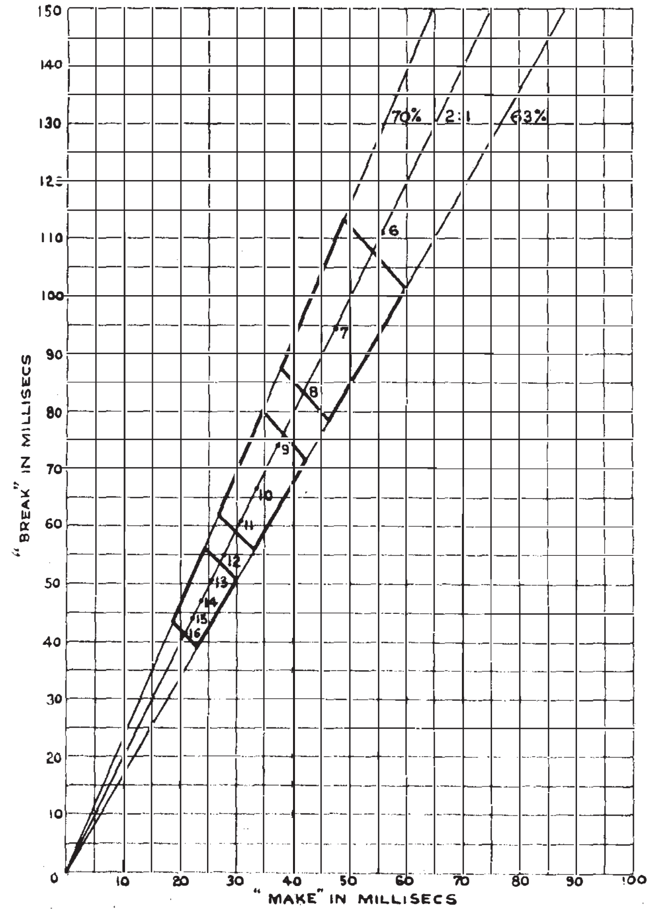


FIG. 4.—DIAL TARGETS FOR 7, 10, 14 IMPULSES PER SECOND.

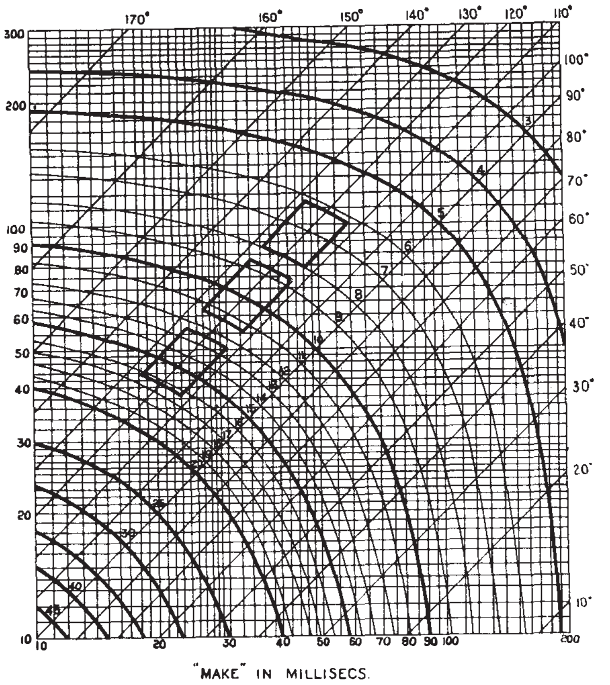


FIG. **5**.—IMPULSE CHART—LOGARITHMIC SCALES.

speeds of 7, 10 and 14 impulses per second respectively, and allowing the same percentage variations as specified for a speed of 10 i.p.s. The permissible variations reckoned in milliseconds are, of course, correspondingly smaller for the high speed and larger for the low speed. This causes differences in the areas of the targets and so tends to give an impression of disproportion.

For all cases therefore where considerable ranges of speed or ratio have to be dealt with we use logarithmic scales as shown in Fig.**5**.* The lines of equal ratio now become parallel while the lines of equal speeds become curves. The effect of the logarithmic division is that a certain distance between the points representing two impulses always represents the same proportionate change no matter on what part of the chart the points occur.

Fig. **5** then represents fully the nature and degree of variability of the impulses delivered by a standard dial at its normal speed of 10 and at the extreme speeds of 7 and 14 impulses per second at which reliable operation of the system is required. It illustrates graphically the impulses which will be applied to the system under the specified conditions.

The next step is to ascertain with what impulses the system is capable of operating reliably. To determine this we carry out impulsing tests on the system or set of circuits to be tested, subjecting it to impulses generated by an accurate interrupter and varying the speed and ratio progressively until signs of unreliable operation become noticeable. For this purpose actual breakdown, that is definite selection of a wrong level or contact, premature release or cutting in of the hunting action, may be taken, but preferably we use the first indication of incorrect operation, such as chattering of the slow relays or signs of overshooting of the switch, even although incorrect selection does not occur. A series of tests of this kind, in which the speed and ratio are progressively varied, enables us to plot the most extreme impulses with which operation is reliable and by joining up the points representing these impulses we obtain a closed figure similar to that shown in Fig. **6**. This diagram we know

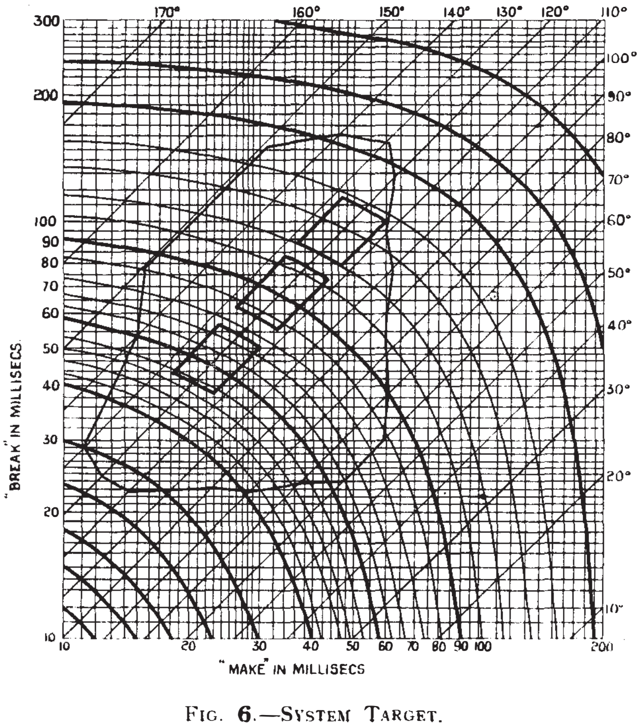


FIG. **6**.—SYSTEM TARGET.

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* *In this figure the ratios are indicated by the number of degrees of break out of a total impulse of 180°, as a matter of convenience, the interrupter referred to later having a scale marked in degrees.*

as the "System Target." The system will accept and operate reliably with all impulses represented by points within the area enclosed by the system target but its operation is unreliable on impulses falling outside that target. By reference to the speed and ratio lines the range of the system in speed and in ratio can be ascertained. By reference to the vertical and horizontal ones the limiting operating conditions can be read off as the lengths of the break and make periods in milli-seconds. The area of the target measures in a general way the range and reliability of the impulsing elements of the system.

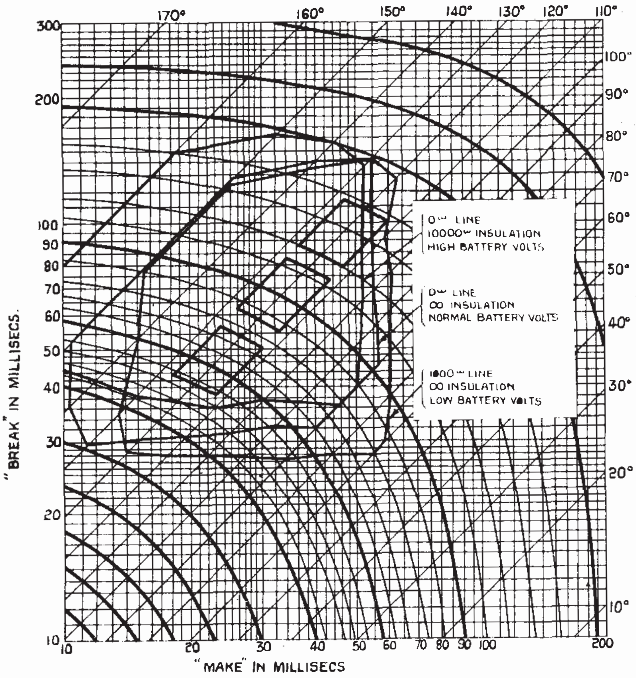


FIG. 7. SYSTEM TARGETS FOR DIFFERENT CONDITIONS.

The separation between the dial targets and system target gives at once a clear mental picture of the margin of safety and on account of the logarithmic scales the impression conveyed is in correct proportion. In a complete study of a system, system targets are taken for all the extreme conditions of varying battery voltage, line resistance and insulation, junction resistance and insulation, etc. Three such system targets are reproduced in Fig. 7 and show the performance of a system under "normal," "long-line" and "low insulation" conditions. In this case, also, each figure represents at each point the performance of the worst of three sets of circuits. Such targets are therefore known as composite targets.

The particular manner in which breakdown or unreliable operation occurs is, of course, different for different parts of the boundary of the system target. By recording against each part of the boundary the manner in which breakdown occurs, we can indicate at once which elements of the system need attention in cases where there is insufficient margin and direct our efforts to extending the boundary at that part.

In such a complicated subject as automatic telephony any device which enables one to display in a concise and readily appreciated manner the relations between a large number of varying factors is extremely useful. We have found this to be particularly true of the targets described in this article. They condense into a single diagram information which cannot be satisfactorily conveyed in words or figures. In simpler engineering matters the degree of safety is measured by the ratio of the breakdown condition to the working condition. Such a definition presumes only one main variable. It is hopeless to try to measure the margin of safety of an automatic system in any such way. As a result of this, ideas on the subject of safety margins on automatic systems tend to be vague and confused. Yet it is of the greatest importance that there should be a margin and that we should know how much it is. The targets we have described have given us clearer ideas and a definite means of measuring our margins. It is with the hope that they may be of equally great assistance to others that we have, with the kind permission of the Board of Editors, brought them to the notice of the readers of the Journal.

THE PHONIC CHRONOMETER FOR THE MEASUREMENT OF RELAY TIMES.

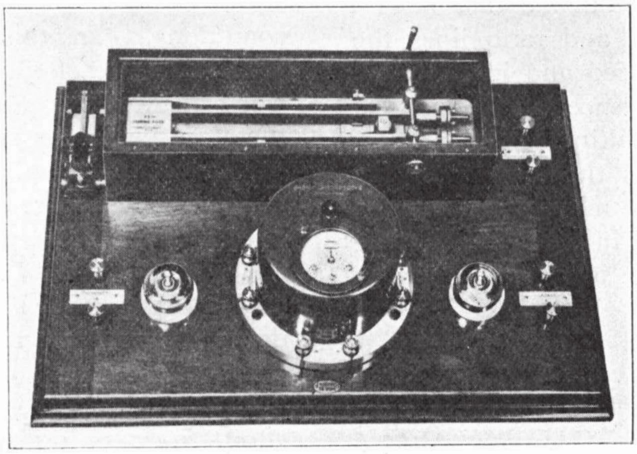
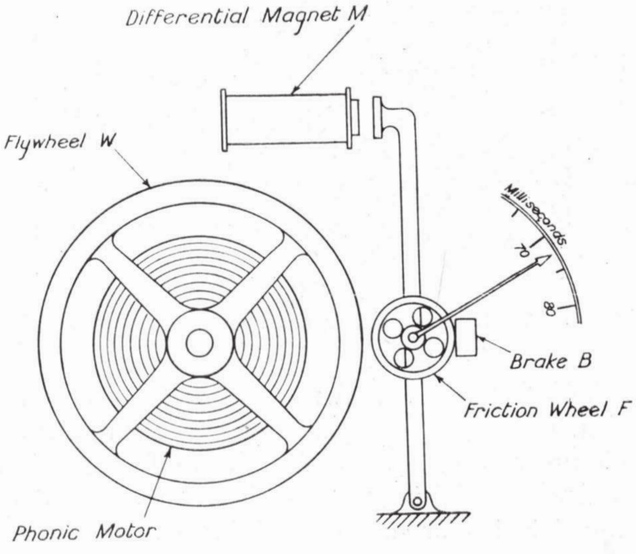


FIG. 1.—THE PHONIC CHRONOMETER.

IT has long been realised that the accurate measurement of operating and releasing times of telephone relays is a vital factor in the design of automatic telephone circuits and up to the present, this class of measurement has always been looked upon as one which can only be carried out by technical engineers with delicate and expensive apparatus. Nevertheless, it has often been suggested jokingly that the Post Office ought to produce an apparatus of the type in which one can " put a relay in a box, turn a handle, and get the operating and releasing lags indicated directly on a dial." The Phonic Chronometer Timing Set has no claims to such an ideal, but it has been so developed by the E.-in-C.'s Circuit Laboratory that it can be handled with ease by the minor staff and can give direct readings which are accurate to a few milliseconds.

The actual measuring chronometer is shown diagramatically in Fig. 2. The essential part of the mechanism is a phonic motor which is driven at constant speed by an electrically controlled tuning fork, the fly wheel of the motor being marked " W " in Fig. 2. Situated a short distance away is a small friction wheel F which can be brought into contact with the flywheel by means of a magnet M. The spindle of the friction wheel is extended to carry a light pointer moving over a scale which is suitably graduated in milliseconds to give a direct reading of the period of contact between the two wheels. In the normal position the friction wheel rests against a back stop B, which also acts as a brake to arrest the rotation of the wheel



Note 1.
The Phonic Motor rotates at constant speed, being controlled by an Electromagnetic Tuning Fork.
Note 2.
The Pointer indicates on the graduated scale the length of time that the wheel F has been in contact with the wheel W.

FIG. 2.—THE PRINCIPLE OF THE CHRONOMETER.

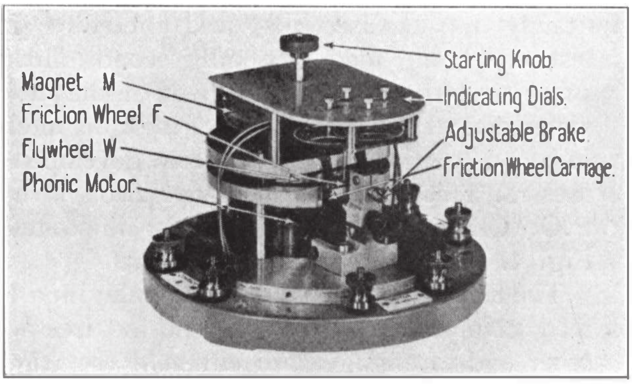


FIG. 3.—THE CHRONOMETER MECHANISM

when the magnet M is released. In order to reduce errors due to differences between the operating and releasing times of the electro-magnet M, the magnet is differentially wound and is so connected that when current is flowing in both coils, the fluxes produced cancel each other and the friction wheel is allowed to remain against the back stop. When one of the differentially wound coils is disconnected, the magnet operates and starts the rotation of the pointer, and when the other coil is disconnected the magnet is released and the pointer is immediately arrested by the brake. It will be seen therefore that the pointer indicates the time period between the disconnecting of the first circuit and the disconnecting of the second, provided that the electrical lags in the magnet are the same at starting as at stopping.

In order to obtain the required accuracy in an instrument of this nature it is necessary to incorporate many refinements to eliminate possible errors such as slip, inertia, eccentricity, magnet time-lags, residual flux, etc. Attention has been paid to each of these points, and a photograph of the actual chronometer manufactured by Messrs. Tinsley & Co. is given in Fig. 3. The various components of the apparatus are indicated and it is seen that the friction wheel and the carriage which holds it are of a very light construction, the travel of the friction wheel being approximately 5 mils. Instead of a single dial and pointer, the instrument illustrated has a train of 4 dials giving readings from 1 m.s. to 100 seconds, the pointers being reset by hand between successive tests. The complete instrument is very compact and only measures $7\frac{1}{2}'' \times 7\frac{1}{2}'' \times 5\frac{1}{2}''$ high.

The part of the apparatus so far described would give time measurements between successive breaks of any two independent circuits with 1 m.s. accuracy, but in order to adapt it to give measurements of relay lags with the required simplicity of operation, it is necessary to add a separate assembly of auxiliary apparatus con-

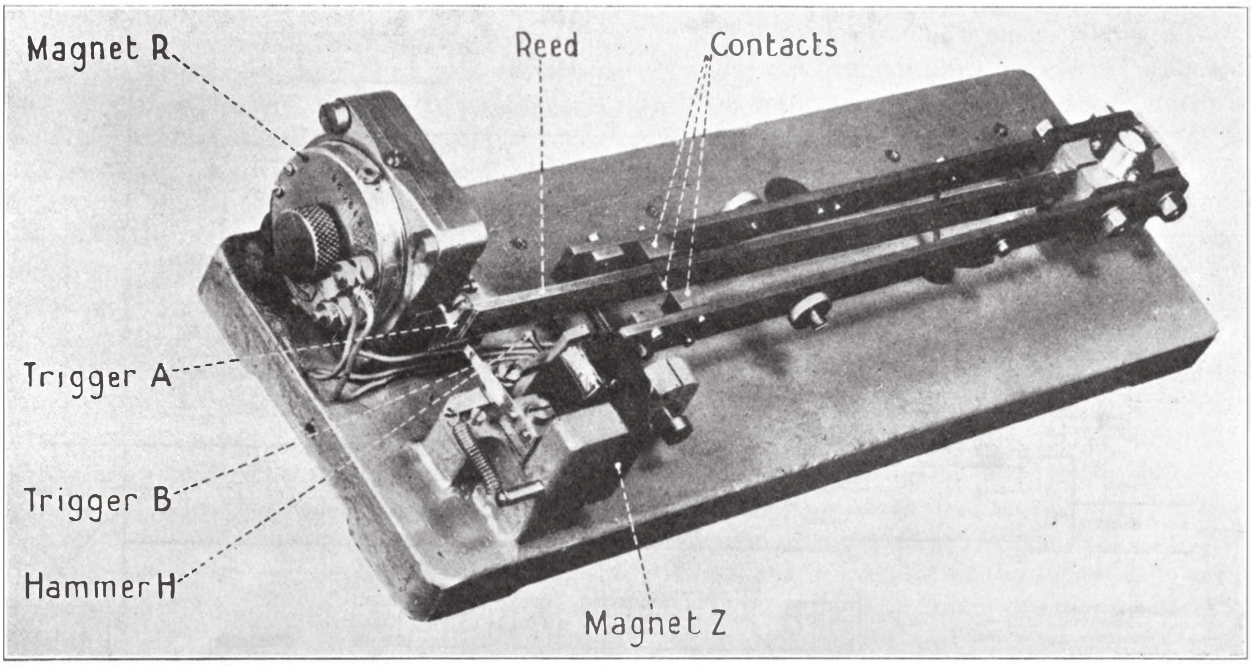


FIG. 4.—AUXILIARY 100 M.S. RELAY.

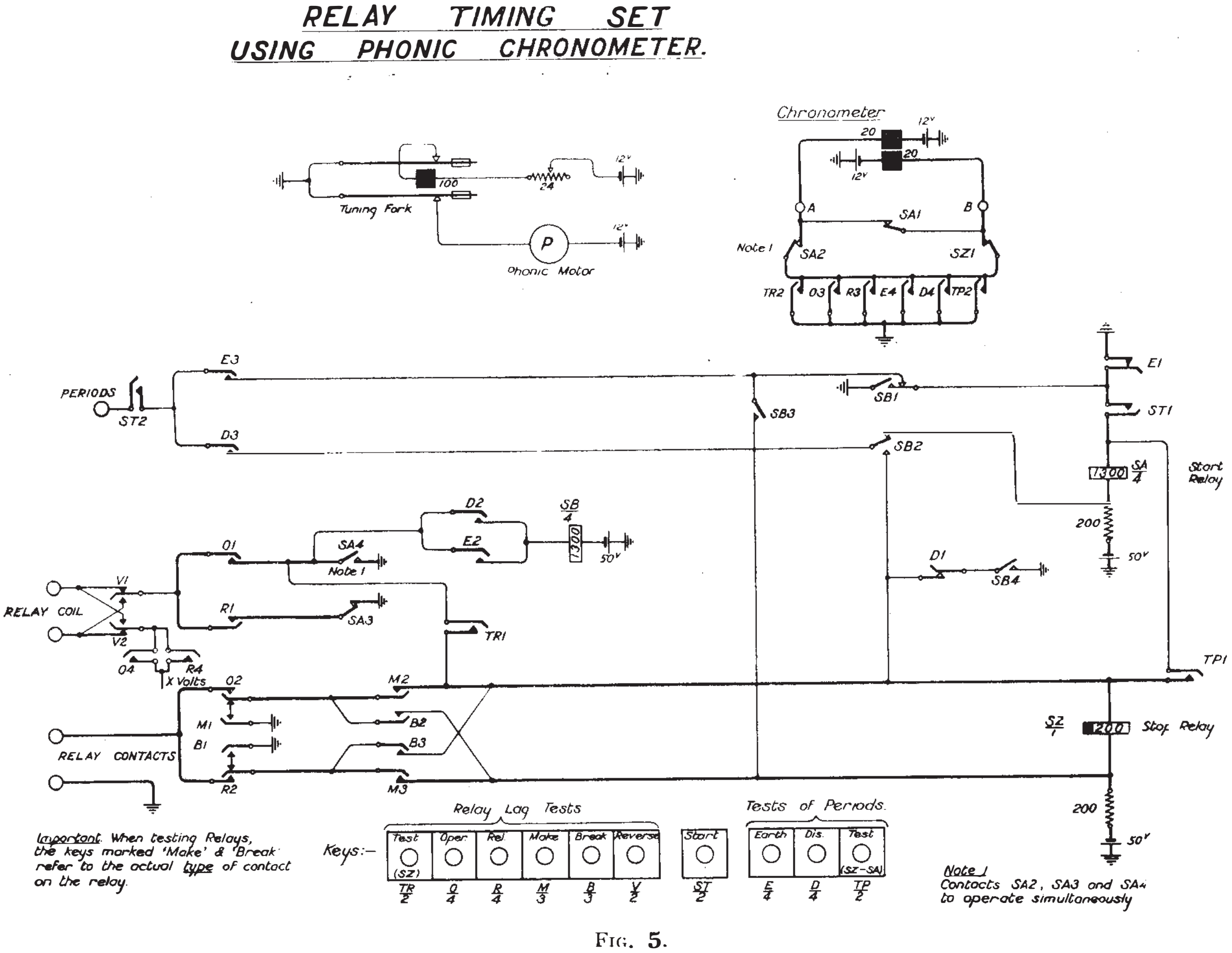
sisting of keys, relays, etc., as shown schematically in Fig. **5**. The complete timing set shown in that diagram provides the following facilities :

(*a*) Measurement of operating and releasing lags of relays with either "make" or "break" contacts.

(*b*) Measurement of the duration of earths or disconnections in any simple circuit.

It will have been observed that there will be an appreciable operating lag in the chronometer itself (approx. 40 milliseconds) and therefore it will be impossible to get a reading on the chronometer dial in the case of an interval of less than this value. As, however, there are many occasions when quite small time lags have to be measured, the auxiliary apparatus has incorporated in it a special relay designated SZ for the purpose of adding a fixed time interval to any period that is being measured. This relay is designed to have an operating lag of exactly 100 milliseconds, and therefore when tests are being made 100 milliseconds must be subtracted from the reading given on the chronometer dial. This special relay is of an interesting construction and has been developed by Messrs. Tinsley & Co. in co-operation with the P.O. Circuit Laboratory. It is illustrated in Fig. **4**.

The armature of this auxiliary relay is a long reed, clamped flexibly at one end but free at the other end to engage with either of the triggers A or B. In the normal position the reed is held by trigger A, but when the magnet R is energised the trigger is raised and the long reed is allowed to swing over with a speed corresponding to its natural frequency. It operates the contacts shown and is held in position by the trigger B which is allowed to come into engagement when the coil Z is energised. The two coils Z and R are therefore connected in series so that when the relay is energised, trigger A is



Important. When testing Relays, the keys marked 'Make' & 'Break' refer to the actual type of contact on the relay.

Note 1
Contacts SA2, SA3 and SA4 to operate simultaneously

FIG. **5**.

lifted and trigger B is engaged. It follows therefore that when current is cut off from the relay, the trigger B will be raised by the action of the Z magnet and, with the help of the small hammer H, the reed will return to the trigger A which will have been restored. The relay is therefore self-restoring and the " follow " of the break contact can be adjusted to give the required operating lag of 100 milliseconds.

Referring to the circuit diagram in Fig. **5** it will be of interest to follow the functions of this auxiliary relay SZ when making some particular test. For example, suppose it is desired to measure the releasing lag of a relay having a break contact. The coil and contacts of the " test " relay will be connected to the terminals shown on the L.H. side of the diagram, the point marked " X volts " being connected to a suitable battery voltage (usually 50v.) and it will also be necessary to throw the " releasing lag key " R and the " break contact key " B. The R3 contact provides earth connections to both of the differential magnet coils in the chronometer and the R1 contact provides a path which keeps the relay under test in the operated position. Included in this " test " relay circuit, however, are the break contacts of the " start relay " SA and this relay will be operated when the " Start Key " is thrown. As the relay under test is in the operated position, its break contacts in this case are open, but as soon as the " test " relay has released there is a circuit for the " stopping " relay SZ *via* the contacts R2 and B3.

With these circuits in mind it will be easily understood that the operation of the start relay SA will simultaneously disconnect the test relay circuit and also the first differential coil of the chronometer; the test relay will then proceed to release and, as soon as its break contacts have closed, the SZ relay will be energised. The SZ1 contacts, however, will not be opened until 100 milliseconds have elapsed and therefore the chronometer will have received a time interval equal to the releasing lag of the relay under test plus the 100 millisecond operating lag of the SZ relay. Similar circuits are provided for the measurement of operating lags and in every case the timing set will give correct readings whether the relay contact be a " make " or a " break." It should be remembered when making relay measurements that the words " make " and " break " refer to the type of contact on the relay and not to its actual function during the testing operation. Provision is made for checking the 100 m.s. operating lag of SZ directly on the chronometer by throwing the " test " key TR.

It is also possible to measure the duration of any earth or the duration of a disconnection period in a circuit which is normally earthed, by using the terminal marked " Periods." In the case of an " earth " period in a circuit, the " earth " Key E is thrown, and then when the " start key " is operated the SA relay is connected to the " Periods " terminal *via* SB1 and E3. When the earth is connected, the SA relay operates and starts the chronometer at contacts SA2, but the relay SB is also operated *via* E2 and SA4. Relay SB switches the " Periods " terminal over from the SA relay to the SZ relay, but now the earth connection being tested is allowed to short-circuit SZ *via* SB3, a separate operating earth being provided *via* D1 and SB4. When the test earth connection is removed, the SZ relay operates and after 100 milliseconds delay the chronometer is stopped. In this class of test the chronometer is only reading higher by an interval equal to 100 milliseconds minus the operating lag of SA. This interval can be measured on the chronometer by throwing the key TP. In this case the SA and SZ relays are connected in parallel and, as soon as the start key is thrown, the chronometer is started by the SA contact and stopped by the SZ contact. The interval between these two operations is the difference between the operating lags of the SA and SZ relays and this is the time interval which would have to be subtracted from the previous chronometer reading. The subtraction of this odd amount detracts from the simplicity of operation, but it is not considered so important as the retention of the exact 100 milliseconds subtraction in the case of the more frequent relay measurements.

Compared with the oscillograph this apparatus has many advantages for general relay work and one of the greatest is the fact that a number of readings can be taken in quick succession by the re-operation of the start key, giving a record of the relay variations from time to time under the same external conditions. It is interesting to note that an ordinary telephone relay will often give readings varying by as much as 10% between successive operations.

The complete instrument has been checked against the oscillograph with results that show an accuracy of approximately 5 milliseconds on intervals up to 500 milliseconds and this is very satisfactory for general relay work. Coupled with this accuracy, however, is the important factor of simplicity of operation, which enables the instrument to be used by the minor staff as well as by the engineers. It may be said that with its aid the measurement of relay times has become as simple and as rapid as the measurement of operating currents.

R. W. PALMER.

THE ACCOMMODATION OF P.B.X. LINES IN A FINAL SELECTOR MULTIPLE.

R. J. HINES, B.Sc.

(I.) STATEMENT OF THE PROBLEM OF DESIGN.

A STUDY of the P.B.X. final selector circuits in use does not reveal all the factors which have been taken into account in designing the scheme. Moreover, it needs considerable experience in circuit analysis to form a clear understanding of the accomplishments and limitations of a particular circuit. Such an understanding is dependent upon the formation of a clear conception of the fundamental principles upon which the circuit operation depends, and it is the intention of this article to provide a summarised description of the facilities afforded by the various P.B.X. final selector circuits working in this country.

No circuit at present in use can be said to be ideal and the present designs have been the outcome of an examination of the ideal requirements followed by an attempt to provide as many of these facilities as could be concurrently provided in one circuit. This article is therefore divided into two parts, the first of which enumerates the considerations which should be taken into account, whilst the second part describes the existing schemes and shows to what extent the desirable features are incorporated.

The fundamental requirement of a final selector in the multiple of which appear P.B.X. lines, is that the busy tone shall not be transmitted to the calling subscriber until all the lines of the called P.B.X. are found to be engaged.

Before commencing to develop a circuit which will meet this requirement, it is necessary to consider how the P.B.X. lines may be grouped, *e.g.*, will the groups all consist of lines having consecutive numbers, or will they be scattered throughout the numbering scheme? The scheme developed for dealing with such groups should place as few limitations as possible on the numbering. The first restriction, nearly always found to be unavoidable, follows from the fact that in general not all the final selectors provided in the exchange are enabled to deal with P.B.X. groups, *i.e.*, the Directory number allotted to P.B.X. groups must be limited to a block of numbers served by special final selectors known as *P.B.X. final selectors*. The reason for employing a special type of P.B.X. final selector is that since additional facilities are to be obtained with these switches a greater number of relays is required in their circuits and they are, consequently, more costly. Hence an economy is obtained by providing no greater number of these more expensive switches than are required to carry the P.B.X. traffic on the exchange in question. The P.B.X. groups of final selectors should not be adjacent, but should be distributed throughout the numbering scheme, so avoiding congestion through certain channels.

The great majority of P.B.X.'s have fewer than 10 exchange lines, and it is therefore desirable that the scheme adopted shall permit the accommodation of more than one P.B.X. group in a final selector level, due regard being paid, however, to the possibility of development and an adequate number of spares, therefore, being left for the growth of each P.B.X. In order that provision shall be made for meeting the needs of subscribers who, though renting one exchange line only, are potential P.B.X. subscribers, it should be possible to place their lines also on P.B.X. final selectors and thus avoid the necessity for number changes when the additional lines mature.

If the total number of P.B.X. groups working on an exchange be very small it may be desirable for direct exchange lines to be interspersed between the lines of one group in order to use the bank capacity to an advantage and yet allow for unexpected development of P.B.X. groups. This facility is at present provided at Southampton only, and is there accompanied by the disadvantage that one P.B.X. group only can be accommodated in a level.

Allowance must be made for the possibility of P.B.X. exchange lines being plugged through to extensions when the P.B.X. board is unattended. In these circumstances it must be possible for individual lines in such a group to be called, *i.e.*, definite advice must be given if the called line is engaged without first testing the remainder of the group. If the automatic hunting of the selector were allowed to take place when the called line is engaged, the call would either be routed to an extension which was not required, or the selector would ring on a line which was not extended to a point where attention would be given and a false " no reply " condition would result. In circumstances when the night service is sufficiently extensive to make this a serious disadvantage, it follows that night service cannot be given by dialling the directory number, as the selector would inevitably hunt when this number was found to be engaged. A night service number must therefore be advertised. This number may be either in the consecutive series allotted to the P.B.X. or may be a special number on a regular final selector bank and jumpered to one of the exchange lines. A special rental is charged when this facility is given.

A further important consideration is that it should be possible to leave spare contacts in the bank multiple and so allow for future growth and yet do so in such a manner that no wastage occurs in the numbering scheme, *i.e.*, provision is made for development without the reservation of numbers which may be required for allocation to direct lines.

The preceding paragraphs deal with the facilities which should be provided for P.B. X. subscribers and does not discuss the practicability of providing all these facilities concurrently. It therefore becomes necessary to consider whether an ideal scheme can be provided and, if so, whether the advantages obtained justify the cost of provision. If an ideal arrangement involves a great deal of difficulty, it is necessary to estimate the value of each facility and balance this value against the difficulty of providing it.

Night service.—As already stated the engagement of the first line of a P.B.X. group must normally result in final selectors rotating over the remaining lines of the group. If a particular exchange line be required, *e.g.*, an exchange line which has been connected to an extension, final selectors must refrain from hunting when that line is found to be engaged and must instead report the engaged condition by connecting busy tone to the calling line. The final selector must therefore be given some indication when it is required to suspend its P.B.X. hunting function. Hence, some variation in the conditions must be made to distinguish between a call to the P.B.X. board and a call to a particular extension. If the call to a particular extension is to be routed by the dialling of the directory number some alteration must be made to its exchange line circuit at the time that the change from normal to night service conditions is required. This obviously involves either co-operation between the subscriber and the exchange staff or some engineering complexity added to the exchange line circuit, enabling the subscriber to vary the condition at the exchange. Either of these alternatives is unsatisfactory, and special night service facilities are not given over the first lines of a group except in special circumstances. It is evidently possible, however, to arrange that night service may be obtained by dialling some number other than that entered in the directory. This number may be a spare number which is teed to the exchange line required, and which is not such as will set up the hunting condition in the final selector circuit, or it may even be one of the auxiliary lines of the P.B.X., so long as this also is a line which will not cause the final selector to hunt. It is possible to adopt this latter arrangement since the normal method of calling the P.B.X. is to dial the directory number and this is the only line that need be arranged to set up hunting conditions in the final selector circuit.

It has already been stated that when it is necessary to provide for P.B.X.'s with large groups of lines, it is very desirable that these lines should not be among those to which numbers in the regular numbering scheme are allotted, *i.e.*, these lines cannot be reached individually by dialling their numbers. If this requirement be satisfied, the only way of providing night service over particular exchange lines is by employing a spare number in the regular numbering scheme and teeing this to the exchange line in question. It is thus apparent that there is a fundamental incompatibility between the requirements that numbers in the regular numbering scheme shall not be alotted to auxiliary lines, and that any line may be called individually.

P.B.X.'s with more than 10 *exchange lines.*—Groups of P.B.X. lines more than 10 in number cannot be accommodated on one level of bank contacts on a final selector of the usual type. In consequence these groups present more difficulty than groups of 10 lines or fewer, as it is necessary either for the final selectors concerned to rotate their wipers over the levels in succession or alternatively to reach these lines by some other channel than usual. Hence these switches are more costly than those which can deal with small groups only. Since the number of P.B.X.'s with more than 10 lines usually form a small percentage of the total P.B.X.'s, it is usual to provide one type of P.B.X. final selector for dealing with small groups, and provide other means for dealing with large groups.

Availability.—It is obvious that large groups of lines may be dealt with by splitting the multiple, *i.e.*, whereas any one switch may hunt over the 10 lines in one level, the 10 lines available to one switch will not be the same 10 lines in the corresponding level of other switches. Such an arrangement, however, results in the reduction of the efficiency of the service given to the subscriber and is not adopted except to a limited extent in special circumstances. (See description of the standard 2-10 line P.B.X. final selector).

Number wastage.—In order to avoid the allocation of large groups of numbers to the auxiliary lines of P.B.X.'s it is sometimes arranged to interpose a special 3rd selector between the 2nd selector and the P.B.X. final selector, *i.e*, the 2nd selector, which normally has access to 10 groups of final selectors, is given access to 100 groups. The 3rd selector is operated by the 3rd dialled digit which would normally define the 10 lines within which the required line or group was situated. The final selector reached, however, has access to more than 10 lines and may either be of a type which first accepts the 4th digit and then, having located the required P.B.X., proceeds to find a disengaged line, or it may be exclusive to one P.B.X. and commence searching over the corresponding group without waiting for the 4th digit, which it will ignore. The use of a special 3rd selector scheme will be dependent upon there being a sufficient saving in exchange numbers to justify the provision of the additional apparatus.

Special P.B.X. line switches.—Schemes have been devised which involve the use of two types of line switch, viz., one type for ordinary lines and another type for P.B.X. lines. Although such a scheme involves little engineering difficulty, it is generally recognised as a principle that any line switch should be available for use with either ordinary lines or P.B.X. lines.

Dialling-in to P.A.B.X.'s.—The schemes at present in use do not provide for dialling P.A.B.X. extensions direct from the public system.

Allocation of Numbers in P.B.X. Units.—The fact that a subscriber rents a P.B.X. indicates that his line will be more busy than those of subscribers with single lines. Congestion through certain channels in the exchange would occur if the P.B.X. lines were placed in units fitted with nothing but such lines. It has therefore been agreed between the Engineering and Traffic Departments that switches to accommodate ordinary lines as well as P.B.X. lines shall be allocated numbers on the following basis:—In every 100 ordinary numbers in the exchange multiple it is assumed that there will be 3% unavailable spares and that in 100 P.B.X. numbers there will be 18% unavailable spares. For example, if the ultimate development be anticipated as 2,051 ordinary lines and 186 P.B.X. lines, the actual numbers will be calculated as follows:—

	Lines.		Factors.		Numbers.
Ordinary lines ...	2,051	÷	0.97	=	2,114
P.B.X. lines ...	186	÷	0.82	=	227
	2,237				2,341

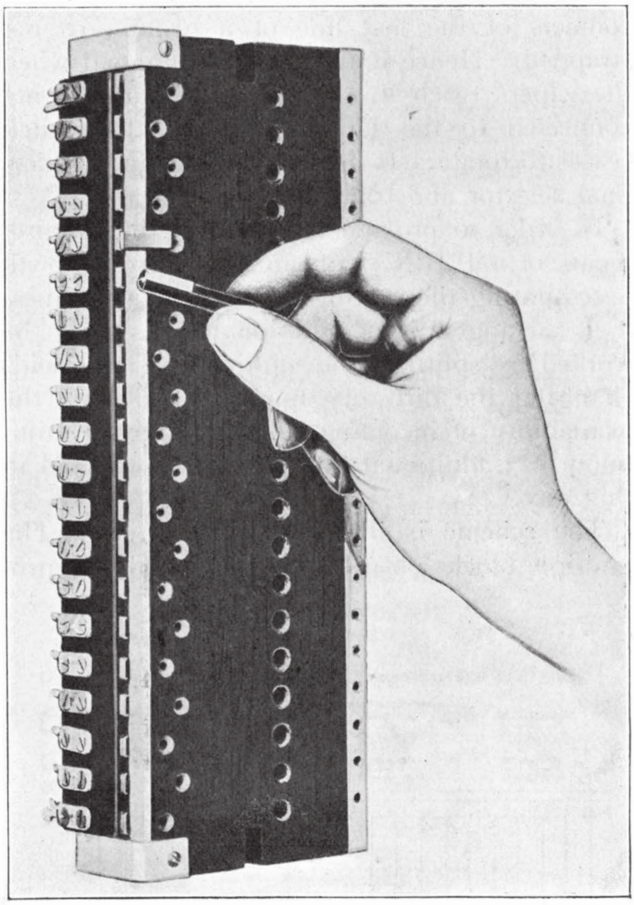


Fig. 1.—Strip of Busying Jacks.

The number of P.B.X. units is estimated as follows:—

To each P.B.X. unit are allocated 60 P.B.X. numbers and 40 ordinary numbers. Thus, in the example above, the number of P.B.X. units will be $\frac{227}{60} = 4$. The estimate that in the ultimate there will be 97% of the ordinary numbers working and 82% of the P.B.X. numbers working, thus implies that there will be 60 × 82% = 49 working P.B.X. lines and 40 × 97% = 39 working ordinary lines per unit = 88%, of the total capacity of the unit.

A further provision is that when the extension is final and when the multiple capacity limits the capacity of the exchange, 86 working lines per 100 P.B.X. numbers should be allowed for, giving a factor of 0.86 instead of 0.82. When this stage is reached there will be 60 × 86% = 52 working P.B.X. lines per unit.

Engaging faulty lines.—If one line in a group be faulty, it is necessary that during the time that the line is receiving attention it should be engaged to final selectors which will therefore pass on to the remaining lines in the group. In order to achieve this end, a strip of jacks of special design is fixed to the verticals of the main frame to which the privates of the P.B.X. units are wired. In order to engage the line a peg is inserted in the jack and this earths the private. A main frame fanning strip fitted with a strip of busying jacks is shown in Fig. **1**.

In the case of Siemens No. 16 equipment, the pegs are normally in position and are withdrawn to disconnect the " C " wire, thus rendering it engaged.

(II.) GENERAL DESCRIPTION OF WORKING SCHEMES.

A.—The Standard Schemes.

Types of selector used.—The schemes now standardised involve the use of three tpyes of selector, viz., one for dealing with groups of 10 lines and fewer, a second for dealing with groups of 11-20 lines and a third for dealing with groups of more than 20 lines.

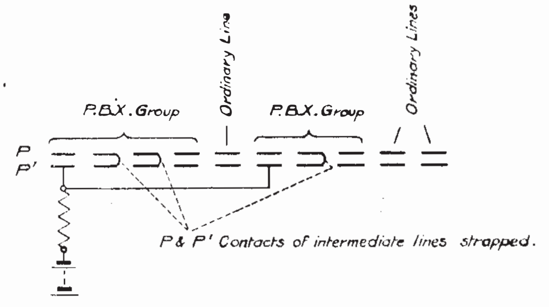
The 2-10 line P.B.X. final selector.—The characteristics of this selector are as follows:—

(*a*) All the lines in one P.B.X. group are accommodated in one level of contacts.

(*b*) More than one P.B.X. group may be accommodated in a level.

(*c*) Any line may be dialled and hunting will only take place if the number dialled is the first line in the numerical sequence of a P.B.X. group and is found to be engaged.

(*d*) Ordinary lines can be interspersed between the P.B.X. groups.



NOTE – The P' Contacts are actually above the P. Contacts but for convenience are represented in circuit diagrams as being beneath the P. Contacts.

2-10 LINE P.B.X. FINAL SELECTOR.

Arrangement of P&P' Contacts.

Fig. 2.

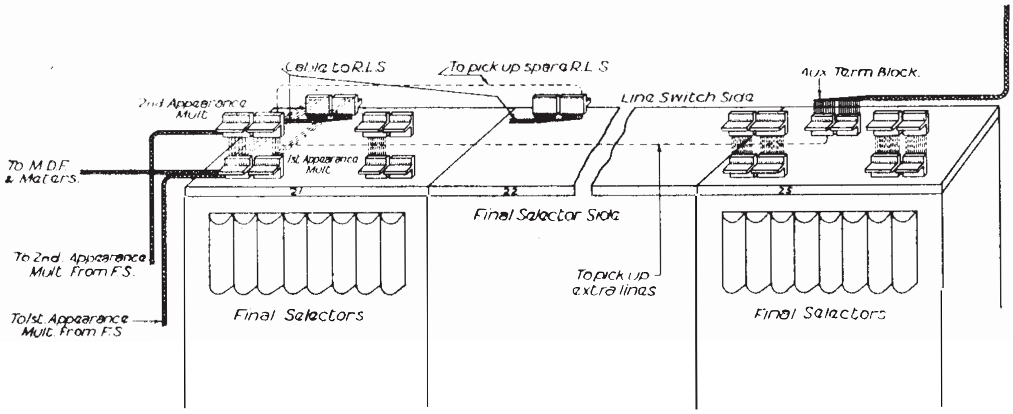
In addition to the above the usual ringing and supervisory functions associated with final selector circuits are performed.

From the above it is obvious that some distinction must exist between ordinary lines and P.B.X. lines and, further, between the first and subsequent lines of a P.B.X. group. The distinguishing characteristics are provided by an auxiliary private circuit. The private bank is constructed like an ordinary line bank and a double private wiper is used, *i.e.*, a wiper having the two halves insulated from each other in the manner of line wipers. The lower wiper completes the normal private circuit to the line switch and the upper wiper completes the local circuit to determine the class of the line called. The private contacts are arranged as shown in Fig. **2.**

The circuit is such that if the first line of a P.B.X. group is called and the private contact is found to be connected to earth, signifying that the line is engaged, the battery on the P1 private contact will complete a circuit to step the switch to the succeeding line. The continuance of hunting over engaged lines is dependent upon the two private contacts associated with each line being strapped together by which means the earth on the private circuit is communicated to the P1 contact. The P and P1 contacts of the last line of a group are not strapped. Hence if this line be engaged when the wipers reach it, the engaging earth is not connected to the P1 contact and the switch ceases to rotate. It then behaves as an ordinary final selector and transmits the busy tone.

In order to provide for meeting the requirements of a P.B.X. with an unexpected growth necessitating the renting of more than 10 lines, it is arranged that additional lines may be worked by splitting the multiple. This avoids changing the directory number, but since the availability of incoming calls is limited a minimum of 3 additional lines only are provided in this way.

The scheme is illustrated in Fig. **3.** The multiple blocks on the top of each unit are pro-



2-10 P.B.X. SELECTOR UNIT.

Showing Double Appearance Jumpering Field

Fig. 3. When extra line is required 2nd Appearance Multiple is jumpered to any spare Line Switch and to Terminal Block to pick up auxiliary line

vided in duplicate, the multiple from half the final selectors in the unit being cabled to the lower block, while the multiple for the remaining switches is cabled to the upper block. The lower block only is cabled to the main frame, the upper block being normally jumpered to the lower block. On the line switch side of the unit can be seen the block to which the line switches are cabled and the line switches are normally connected to their proper position in the multiple by jumpering from these blocks to the first appearance multiple block. All the line switches of a P.B.X. group of 10 lines are thus available to the whole of the final selectors in the unit. Should an additional line be required, the jumper connecting the 10th line between the first and second appearance block is removed. The 10th line is thus available to the first half of the multiple only. It is now necessary to connect the 10th circuit on the upper block to an additional line and associate this line with a spare line switch. In the figure it will be seen that the upper block has been jumpered to a line switch and also to a miscellaneous terminal block. This latter jumper serves to connect to an extra line, the miscellaneous block being cabled to the I.D.F.

There are thus two lines corresponding with the last outlet on the level and the additional line is, therefore, allotted a number outside the regular numbering scheme of the exchange. A special group of meters is provided for such lines and connection with these meters is made at the I.D.F.

One miscellaneous terminal block is usually provided per suite of units—generally 5.

The 11-20 line, P.B.X. Final Selector.—The characteristics of this selector are as follows:—

- (*a*) Each level accommodates 20 lines (by means of two banks as described below).
- (*b*) One P.B.X. only can be accommodated per level.
- (*c*) The wipers are not dialled into the level but rotate automatically as soon as the vertical stepping is completed.
- (*d*) Although 20 lines are allotted to each P.B.X. 10 numbers only are sacrificed since there are two lines for every possible position of the wipers.
- (*e*) It follows from (*c*) that individual lines

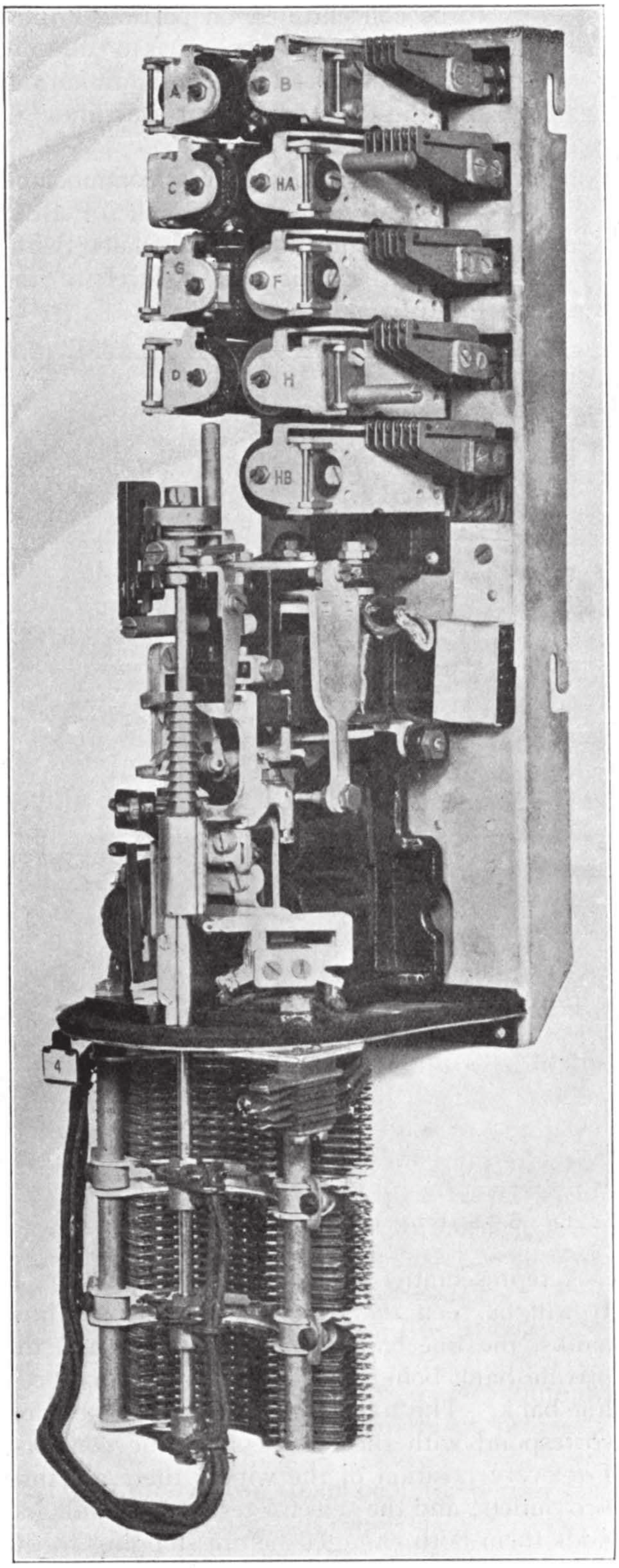


FIG. 4.—SELECTOR FOR GROUPS OF 11-20 LINES.

cannot be dialled and for night service to be concentrated on particular lines it is therefore necesary to allocate special numbers in regular units and tee these numbers to the lines in question.

(*f*) Ordinary lines cannot be accommodated on this selector. Small P.B.X. groups cannot be accommodated (without the sacrifice of a level to the group).

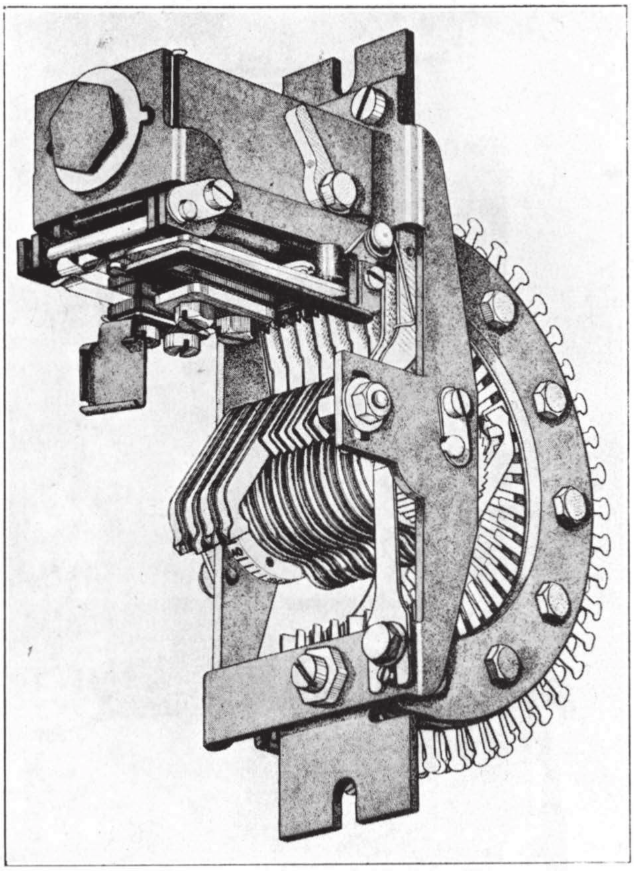


FIG. 5.—SELECTOR FOR GROUPS EXCEEDING 20 LINES.

A representative selector is shown in Fig. **4**. It will be seen that this selector carries three banks, the line bank being duplicated and the private bank being similar in construction to a line bank. The 200 contacts of the private bank correspond with the two sets of line contacts. For every position of the wipers there are thus two outlets, and the selector tests both these and finds them both engaged before stepping to the next position. If both the outlets are found to be free, the selector seizes the lower circuit and does not interfere with the upper circuit. For the convenience of the Maintenance Staff, these selectors are provided with 6-point test jacks, the two extra springs being for the purpose of indicating whether it is the upper or lower outlet that has been seized. If the upper outlet has been taken by the selector these springs, when brought into contact, complete the circuit of a buzzer.

Selectors for groups exceeding 20 *lines.*—Groups of lines exceeding 20 in number are dealt with by a final selector which is individual to the P.B.X., *i.e.*, the *P.B.X.* is identified when the wipers of the penultimate selector have been raised to the required level, all the outlets of which have access to final selectors allocated to the P.B.X. required. The final selector is not controlled by dialled impulses but as soon as seized proceeds to rotate its wipers in search of a free line. This selector is illustrated in Fig. **5** and will be seen to be of the R.L.S. type, from which it differs, however, in that it possesses two sets of wipers. These wipers travel in succession over two adjacent sets of bank contacts. The two sets of wipers are at 180° to each other, so that when one set has completed its travel over the left bank of contacts the other set then commences to hunt over the right hand set of contacts. Since there are 24 outlets in each set of contacts the selector thus gives access to a maximum of 48 outlets. P.B.X. groups exceeding this number of lines may be dealt with by two such selectors operating in series, the second of the pair continuing the search when the first has found all its outlets to be engaged.

If these final selectors are reached from the levels of 2nd group selectors, it will be apparent that their use involves a number wastage since each level of 2nd group selectors normally gives access to a 100 lines, whereas large groups P.B.X. final selectors will be used for all groups exceeding 20 lines. Should the number of such large groups be sufficiently great to involve an excessive number wastage special 3rd selectors may be interposed between the 2nd group selectors and the final selectors.

Night service over predetermined exchange lines can be given only by the use of spare numbers in regular units, as in the case of the 11 to 20 P.B.X. final selectors.

B.—Siemens No. 16 System.

Messrs. Siemens Bros. standard system for large public exchanges is known by them as the No. 16 equipment. This has been described in Mr. C. W. Brown's paper before the I.P.O.E.E. The relays controlling the selector operations are not assembled on the selector mountings but are carried in separate cradles. Conversion of an ordinary final selector is effected by changing the relay set and making a small attachment to the mechanism. The changing of the relay set is effected by lifting the existing set from its cradle and substituting it by the P.B.X. circuit. The attachment to the mechanism consists of a metallic arc clamped to the top of the bank, a wiper assembly and, in the case of selectors for groups of more than 10 lines, a release magnet controlling the rotary motion only. A selector for groups of lines up to a 100 in number is shown in Fig. **6**.

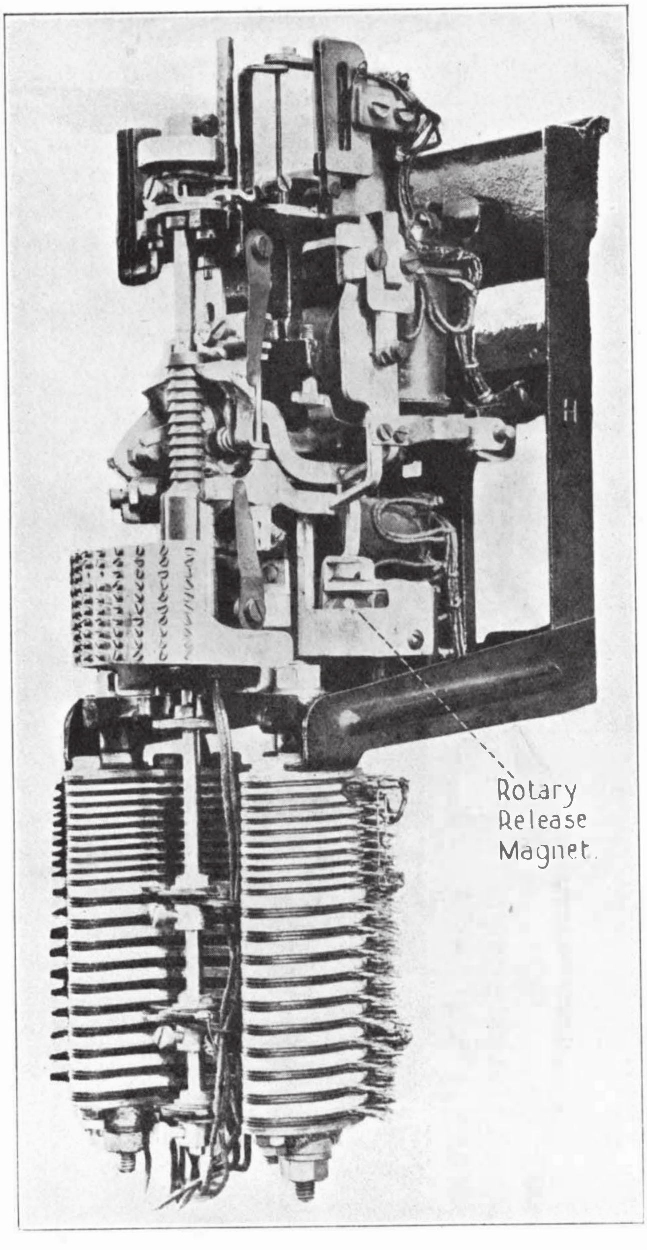


Fig. **6**.—Selector for large P.B.X. Groups. Messrs. Siemens No. 16 Equipment.

The P.B.X. arc will be seen to carry a number of screws. Mounted on the shaft is a wiper which makes contact with the tip of the screws as it rotates. The arc is drilled to carry 100 screws, each screw hole corresponding with one of the lines accommodated in the bank. The fact that the wiper is earthed when it makes contact with one of these screws constitutes an indication that the line being called is one of a P.B.X. group and the selector will hunt if this line is found to be engaged. If no screw be placed in the hole corresponding with the last line of a group, the P.B.X. hunting condition in the circuit is released and the wipers will come to rest, busy tone being transmitted if the whole group has been found to be engaged. The auxiliary wiper assembly actually consists of two wipers—one trailing behind the other. When the selector is stepped from the first to the second line, both auxiliary wipers are therefore earthed. If an intermediate line be dialled, the fact that both wipers are earthed prevents the hunting action from commencing.

Selectors for large groups are fitted with the rotary release magnet shown in Fig. **5**. When the selector has tested all the lines in one level and found them to be engaged, the rotary release magnet is energised. The wipers travel backwards over the level are raised to the next level and proceed to continue the search. In this way the whole bank may be covered.

The characteristic features of the scheme are summarised below:—

(1) No special bank design is required, addition being made to an ordinary mechanism.

(2) Ordinary lines can be interspersed between P.B.X. groups.

(3) More than one P.B.X. group can be accommodated per level.

(4) Any line may be dialled and hunting

will only take place if the number dialled is the first line in the numerical sequence of a P.B.X. group and is found to be engaged.

(5) The large group selector will accommodate groups of any size from 2—100 lines and also direct exchange lines.

(6) The small group final selector is readily convertible into a large group switch.

C.—Siemens P.B.X. Selectors for the Director System.

Selector for groups of 2-10 *lines.*—It will be realised that the small group final selector of the No. 16 equipment provides the same facilities as the standard scheme and Messrs. Siemens Bros. have therefore retained the circuit principles of the No. 16 switch. A double private bank is used and in this respect the switch is standard, but the second private circuit is not connected as in other contractors' circuits (*i.e.*, P1 contact of first line of a group to battery; P and P1 contacts of intermediate lines strapped). Instead, the P1 contacts of all except the last line of a P.B.X. group are connected to earth. A trailing wiper is employed as in the No. 16 system and the dialling of an intermediate line, therefore, brings both P1 wipers in contact with earth. In these circumstances, the selector will not hunt if the line dialled is found to be engaged.

The features distinguishing Messrs. Siemens scheme are as follows:—

Messrs. Siemens Circuit.

All P1 contacts but the last of a P.B.X. group are earthed. P1 contacts of ordinary lines and of the last line of P.B.X. groups are dis.

Night service given on lines other than the first due to the fact that the trailing wiper is earthed, short-circuiting the hunting element of the circuit.

Other Contractors' Circuits.

First P1 contact of group to battery; intermediate P1 strapped to P; last P1 dis. P1 of ordinary lines dis.

Night service given on lines other than the 1st by virtue of the fact that there is no battery on the P1 contacts to start hunting.

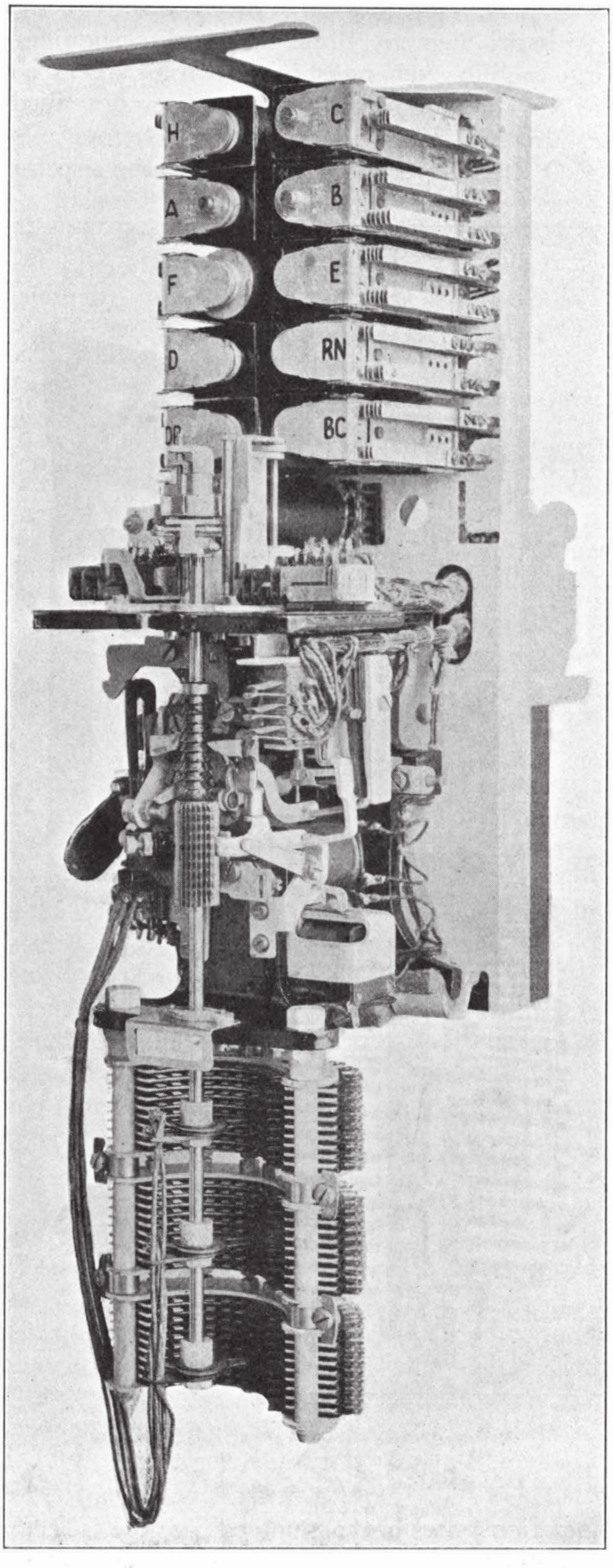
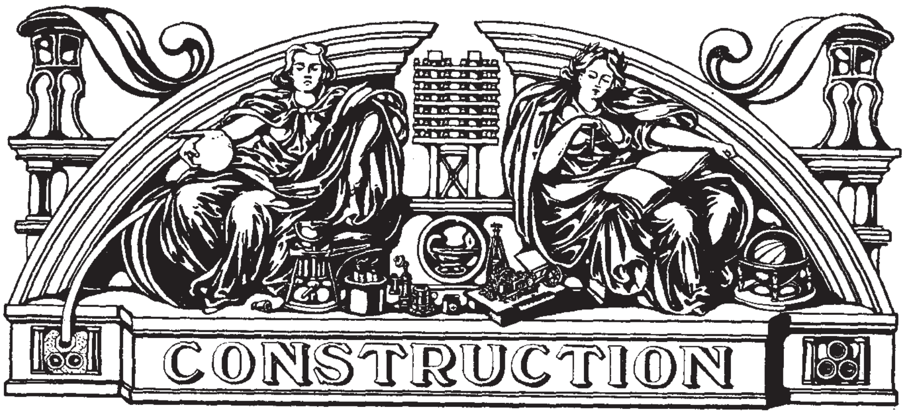


Fig. 7.—P.B.X. Final Selector over 20 Lines. Messrs. Siemens Switch for the Director System.

Selector for groups of 11-20 *lines.*—This selector provides the facilities obtained with the switch described under A, but differs in the method of operation. Two line banks are provided, but instead of a search being conducted over the two banks simultaneously, the wipers enter the bank twice to complete the hunting over 20 lines. One set of wipers is connected in circuit each time and if after the first rotation over the level no outlets are found disengaged in that bank, the wipers are released from the bank and a second search takes place, this time over the lines in the other bank.

Selector for groups of over 20 *lines.*—This selector gives access to a maximum of 200 lines and differs entirely from those of other contractors. It will be recalled that these employ a rotary line switch type of selector individual to the P.B.X. The Siemens selector is a 2-motion switch carrying two banks and will accommodate a maximum of 10 P.B.X. groups. The operation resembles that of the switch for groups of 11-20 lines in that the wipers enter a level twice to complete the search over 20 lines. If the called P.B.X. has further lines in the next level, the wipers are once more released, raised to the next level and the search continued. If all lines to the P.B.X. are engaged, the wipers are driven to the 11th contact of the level containing the last choice and remain there while the busy tone is transmitted.

Fig. 7 is an illustration of this selector. The author is indebted to Mr. Grinsted, of Messrs. Siemens Bros., for this photograph.



CONSTRUCTION OF MANHOLES IN WET SITUATIONS.

THERE are in the South Lancashire District, adjacent to the Mersey Estuary, considerable areas of country where the sub-soil consists entirely of sand, and in these districts water is frequently encountered at 2 ft. or even less from the surface. The construction of concrete manholes in such ground often presents considerable difficulties. The use of a tarpaulin to keep the water away from the concrete until setting has taken place is not found to be entirely satisfactory, chiefly because (1) it is necessary to cut the tarpaulin to allow new and existing ducts and cables to enter the excavation, (2) a satisfactory sump hole cannot be provided in the manhole when a tarpaulin is used, and (3) it is usually necessary to excavate an independent temporary sump hole, the bottom of which must be lower than the manhole excavation. As regards (3), the additional excavation, if the ground be very bad, increases the displacement of sand in the area adjacent to the work, and consequent risk to adjoining buildings and in the best circumstances adds appreciably to the cost of the work. In such conditions the method of construction described below has been found satisfactory.

The excavation is, of course, close timbered on all sides. In certain cases tongued and grooved timber has been used, but this is hardly necessary and is, of course, more expensive than the method employing ordinary timber. The running boards used are of sufficient length to go two or three feet below the bottom of the excavation. It is found that by driving them to at least this depth below the level to which, at any moment, the excavation has been carried, the removal of the contained sand is greatly facilitated, and the displacement of sand around the excavation is much diminished. As the boards are driven in, straw is packed tightly in behind them by means of a spade, and this straw is carried down with the boards. This tends to ensure that only water will ooze through the joints in the timbering, the sand being held back. When the proper excavation depth has been reached, and this may conveniently be 19½″ below the finished floor level, a tightly fitting floor of 1½″ boards is hammered down, covering the entire surface

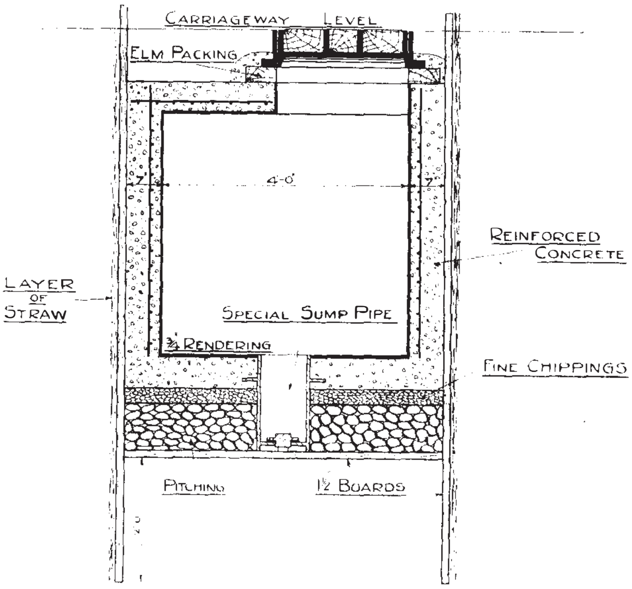


Fig. 1.—Manhole for Wet Situation.

between the running side boards. For this flooring tongued and grooved boards may be usefully employed. On this floor the special sump pipe (Fig. **2**) which, as will be seen, is provided with a screw plug, is placed, the plug being for the present omitted. The floor is then covered with a layer of 9″ of stone pitching. On this is placed a 3″ layer of fine stone chippings to keep the concrete out of the pitching, and finally the concrete of the floor, 6″ thick, is placed in position. The nose of the flood-gate pump is kept in the sump pipe and it is found that in the conditions described the pump draws only water, no sand reaching the sump pipe. The pump is kept going while the concrete is being put in and for about 24 hours thereafter. When all is in readiness for rendering, the screw plug is screwed into position in the sump pipe, the latter then being partially filled with concrete in the usual way. In some earlier cases the sump pipe used was an open pipe, the partition and screw plug being omitted and the pipe being finally closed by means of a wooden plug tightly driven home. This was seldom quite satisfactory, as difficulty frequently arose in getting the plug to fit tightly in the rather roughly cast pipe, and on the whole the use of the more expensive screw plug pipe is found to be the more satisfactory practice.

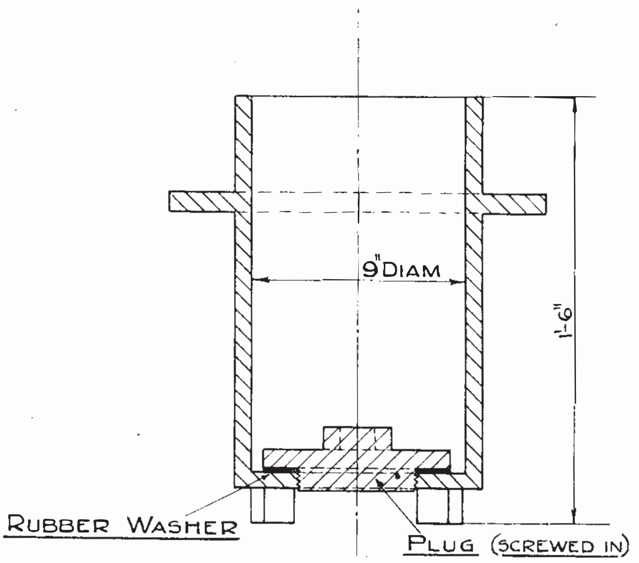


FIG. **2**.—ENLARGED VIEW OF SPECIAL SUMP PIPE SHOWN IN FIG. **1**.

Absolutely water-tight manholes have been constructed in very bad ground by the method described.

A point worthy of notice is that this method largely avoids the displacement of sand by the pump from the ground adjacent to the manhole site. Where manholes have to be constructed close to the foundations of buildings, this is of course of very great importance, as unnecessary disturbance of the adjacent sand may endanger the buildings.

TRANSFORMATION OPERATORS IN SCHEDULED JOINTING PRACTICE.

A. MORRIS, A.R.C.Sc., D.I.C., Wh.Ex., M.I.E.E.

SYNOPSIS.—Introduces the method of Transformation Operators for dealing systematically with crosses between the wires of communication circuits. Explains the use of such Operators by applying them to the Selecting and Scheduling processes involved in cable balancing for interference elimination purposes. Illustrates the simplification which they effect, with consequent lesser liability to error. Points out their great advantage in cases of multiple selecting for normal balancing and their especial utility for the selections involved in rebalancing work. States that they may also be used for the selections involved in rendering circuits electrically uniform, and in dealing with unbalance characteristics in general.

Introduction.—The object of this article is to describe certain Transformation Operators and the method of applying them to the crossing of wires in communication circuits. In their application to wire crossings for interference elimination purposes, such operators considerably facilitate not only normal scheduling and selecting procedure, but also and particularly that involved in any rebalancing work rendered necessary by reason of cable diversions or during the course of ordinary cable maintenance proceedings. Their use may be extended to wire crossings for rendering circuits electrically uniform, as in the jointing of cables for mutual capacity uniformity. Wire crossings for the purpose of dealing with interference characteristics in general can also be similarly dealt with. These operators have been embodied in British Post Office circuit jointing practice, in varying degrees, during the last five or six years.

The general method of balancing referred to in this article for the purpose of illustrating the use of Transformation Operators is known as the "crossing method." In this method the unbalances of one cable length are neutralised by those of other cable lengths which, for the sake of uniformity, should preferably be consecutive lengths. Neutralisation of, for example, the whole of the capacity unbalances of every circuit is thereby effected, over as short a length as possible, by means of the insertion of suitable crosses between the wires at cable joints. Conductor resistance, electrostatic capacity, inductance, etc., unbalances can be separately dealt with by this method, the appropriate wire crosses for their elimination being suitably chosen. With cables of modern manufacture this method permits of practically perfect balance. In Pupinised cables, balance is effected over a length of cable equal to the spacing of the loading coils, *i.e.*, a loading coil section; the capacity balance being almost complete over each group of four standard lengths. Balance secured in this manner, at such relatively short intervals, is essentially uniform and is accordingly independent of frequency.

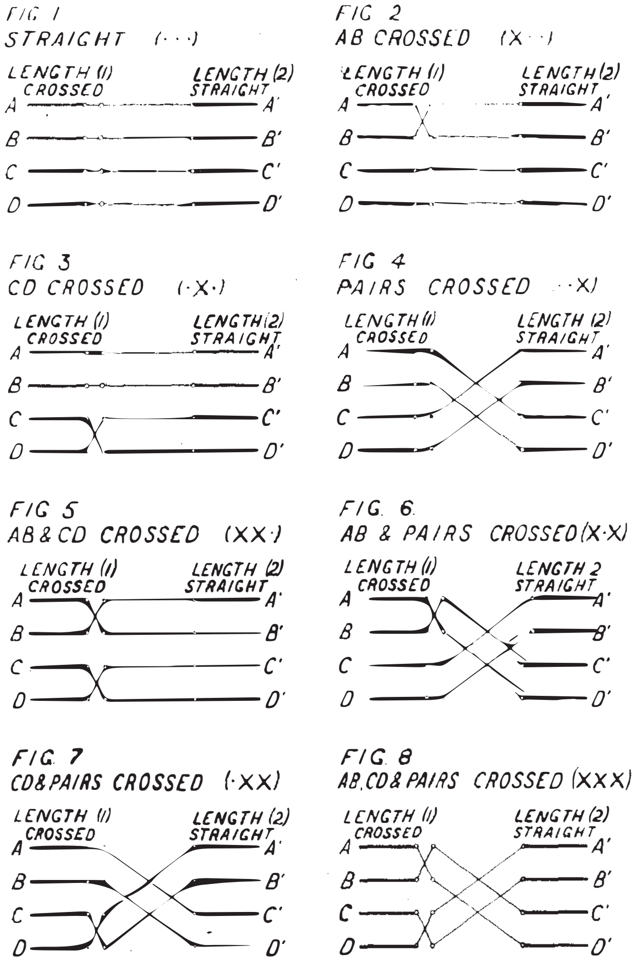
In principle the crossing method is the same as that devised by Tremain and Martin in 1899 for the elimination of cross-talk between the side circuits of Quad type cables, although it is applied in a somewhat different manner. Whereas originally the best type of cross was determined by experimental trial involving measurements of disturbance, both before and after jointing the cable lengths together, the present practice of measuring those electrical characteristics which are contributory to cross-talk enables the best mode of connection to be pre-determined and the final result accurately forecasted. This is rendered possible not only on account of the completeness of the knowledge of the effects of each and every type of cross, but also by virtue of the accuracy of the analysis and measurement of the electrical unbalances of cable cores. Upon this knowledge is based the systematic method of scheduling and selecting test results, which forms one of the important features of this method of balancing.

The crossing method is in general use in the United Kingdom, the United States and in most European countries excepting Germany. The details of application of the method differ in different countries. The principles of the method are described in articles contributed to the Journal, *I.P.O.E.E.*, Vol. VII., Part 1, of April, 1914, and Part 4 of January, 1915, by Mr. S. A. Pollock. The British P.O. Technical Instruction XIX., of July, 1914, amended March, 1919, describes in detail the whole procedure adopted by that Administration. British Patent Specification No. 2508 of 1913 (Convention date 11th April, 1912); O. B. Blackwell and G. A. Anderegg, deals with the procedure adopted by the American Companies. British Patent Specifications No. 2009 of 1913 (Convention date 11th April, 1912); G. A. Campbell, O. B. Blackwell and E. H. Colpitts, and No. 203,870 of 1922, W.E. Co., and D. Nunn deal with the measurements made in accordance with the American practice.

Methods of joining Cores together.—In joining the wires of cable lengths together, the core units must remain intact. Thus complete four-wire cores must be joined together, whilst complete pairs of one core, whether of the twin type as in M.T. cables or of the diagonal-pair type as in Quad type cables, must be joined to complete pairs of the other core. Departure from this arrangement would violate one of the main principles of cable construction, whereby the association of the two halves or limbs of a circuit by the simple process of twisting them around each other, is fundamental to the absence of interference from electromagnetic and electrostatic effects.

Even with the limitation in regard to the preservation of core type, there are eight possible ways of jointing two four-wire cores together.

Figs. (1) to (8) illustrate all the permissible methods of joining the four-wire cores of dry core cables by means of various crosses between the wires. For the purpose of accurately describing each mode of connection it is necessary to regard all the crosses between wires of any two cores as being made from one side of the joint only, *i.e.*, it is necessary to "refer" the cross to one length or the other. The cable length on the side from which the crosses are regarded as being made is called the "crossed length," that on the other side the "straight length." The necessity for this convention arises in the two cases illustrated in Figs. (6) and (7). In Fig. (6) the crosses introduced are accurately and fully described as "AB and pairs." If, however, there had been no indication as to which was the crossed length, the crosses may have been variously described as "AB and pairs" or "C′D′ and pairs," according as length (1) or length (2) was considered the crossed section. Similarly for the crosses illustrated in Fig. (7). The convention described above has been made solely for the purpose of accurately describing in as few words as possible, or for describing symbolically (see next paragraph) the particular mode of connection of the wires of two cable cores. For any particular mode of connection, the crosses are actually neither on the one, nor the other set of wires. This conventional idea is necessary to the theory of cable balancing; it is totally unnecessary in furnishing instructions to a cable jointer as to the required mode of connection of two cores. Fortunately, in this latter connection the colour scheme of the cable is adequate to the purpose and full use should be made of it.



FIGS. ILLUSTRATING TYPES OF CROSSES.

Symbolical representation of wire crosses.—In order to facilitate the writing down of the various types of cross between the wires of cable cores, a symbolical method of representing the crosses is adopted, the basis of which is as follows:—

Fig. (1). Straight. Represented thus:— (. . .)
,, (2). AB crossed. ,, ,, (X..)
,, (3). CD crossed. ,, ,, (.X.)
,, (4). Pairs crossed. ,, ,, (..X)

The symbols for the other types of cross are derived from the foregoing thus:—

Fig. (5). AB and CD crossed.
Represented thus:— (XX.)
,, (6). AB and pairs crossed.
Represented thus:— (X.X)
,, (7). CD and pairs crossed.
Represented thus:— (.XX)
,, (8). AB, CD and pairs crossed.
Represented thus:— (XXX)

With the method of connection of the wires illustrated in Figs. (1), (2), (3), (4), (5) and (8) the particular symbolical method of representation adopted in each case will apply whichever cable length is regarded as the crossed length. In the case of the connections represented in Figs. (6) and (7), however, if length (2) be regarded as the crossed length, *i.e.*, if the crosses are referred to the A′B′C′D′ core of length (2), the symbolical representation will be (.XX) and (X.X) respectively.

Crossing Operators.—The symbols described above are given a greater significance than the mere representation of the type of cross between the wires of two cores. They are regarded as operators which perform certain changes in the regular order of the wires of a core of a cable length before it is jointed to the wires of a core of the preceding cable length. The regular order of the wires of a core, whose pairs are AB and CD respectively, being arbitrarily fixed as A,B,C,D, the Crossing Operators are defined and written down as follows. Thus :—

(1). ABCD (. . .) ≡ ABCD .
(2). ABCD (X..) ≡ BACD .
(3). ABCD (.X.) ≡ ABDC .
(4). ABCD (..X) ≡ CDAB .
(5). ABCD (XX.) ≡ BADC .
(6). ABCD (X.X) ≡ CDBA .
(7). ABCD (.XX) ≡ DCAB .
(8). ABCD (XXX) ≡ DCBA .

If to the wires A′B′C′D′ of the straight length, the wires ABCD of the crossed length are jointed with, for example, an AB and pairs cross, then A′ will be jointed to C, B′ to D, C′ to B and D′ to A. Symbolically and making use of the Crossing Operator, these connections may be represented thus :—

Core A′B′C′D′ to core ABCD with an AB and pairs cross on the latter core,

≡ A′B′C′D′ to ABCD (X.X)
≡ A′B′C′D′ to CDBA
≡ A′ to C, B′ to D, C′ to B, D′ to A.

A further and much more important use of Operators for the purpose of effecting transformations in core unbalances and core interference characteristics now follows.

Transformation of Core Unbalances and Core Interference Characteristics.—The normal unbalances and the normal interference characteristics of a core are perfectly definite and invariable quantities for that core. They are always defined in reference to a certain regular identification and order of arrangement of the wires of a core, taken in conjunction with their associated electrical features. Thus for a four-wire core in which AB is one pair and CD the other pair, the regular or straight order of the wires will be ABCD, whilst the normal capacity unbalances and interference characteristics (which refer to the core when straight) will be in accordance with definition, *e.g.*, as in British Post Office T.I. XIX., for the case of within-core unbalances. Referring to within-core unbalances for the purpose of illustration, if for the purpose of connecting a core to another core in one of the recognised modes, its wires at one end are regarded as being crossed in an appropriate manner, there will be a new arrangement of its wires and consequently a transformation of its unbalances and interference characteristics; *i.e.*, the unbalances and interference characteristics of the core, referred to the new arrangement of the wires at one end, will be the result of some transformation of its normal unbalances and interference characteristics. In order to obtain the transformed unbalances and interference characteristics of a core for any particular type of cross, *i.e.*, to obtain the unbalances and interference characteristics referred to the crossed end of the core, it is necessary to consider the effect of the cross on :—

(i) The arrangement of the wires.
(ii) The arrangement of the associated capacities, w, x, y, z, a, b, c, d.
(iii) The arrangement of the wire to wire unbalances, $(w - x)$, $(z - y)$, $(w - z)$, $(x - y)$ and of the wire to earth unbalances $(a - b)$ or u, $(c - d)$ or v, $(a + b - c - d)$ or f.
(iv) The arrangement of the interference characteristics, $(p - q)$ or $(r - s)$ or γ, $[2(p + q) + u]$ or α, $[2(r + s) + v]$ or β.

Table No. 1 has been compiled to show the whole of the transformations effected by each of the various types of cross which may be applied to a core for capacity balancing purposes. The Table is derived absolutely from first principle considerations. A detailed study of the table in conjunction with fundamental definitions, supplemented by longitundinal diagrams of the core showing the associated capacities, will make an understanding of the transformations much clearer than would a lengthy written description. Similar Tables may be prepared for resistance and inductance balancing purposes.

Unbalance and Interference Characteristic Transformation Operators.—Operators similar to those which have already been described in connection with the re-arrangements effected in the order of the ends of the wires consequent upon the application of the various types of cross, are used to effect transformations of the unbalances and of the interference characteristics of a core. Each of the eight operators are, for within-core capacity balancing purposes, defined as in Table No. 2, which is, of course, in accordance with the results of Table No. 1. Table No. 2 may be extended to include between-core unbalances and interference characteristics. Tables similar to Table No. 2 may also be prepared for resistance and inductance balancing purposes.

Rules relating to the application of Transformation Operators.—Tables 1 and 2 form the basis of the crossing method of cable balancing. The results expressed in these tables are in constant use for selecting and scheduling purposes, and it will obviously be of the greatest convenience if the transformations, effected by any type of operator, can be written down at once without reference to the Tables or to first principle considerations. In order to assist in attaining this object, attention is drawn to the following rules which are applicable to capacity balancing, namely:—

Rule (1). Cross AB. The operator (X..) changes the sign of the pair-to-pair interference characteristic (γ), of the AB to phantom interference characteristic (α) and of the AB to earth unbalance (u). There are no other changes within the core.

Rule (2). Cross CD. The operator (.X.) changes the sign of the pair-to-pair interference characteristic (γ), of the CD to phantom interference characteristic (β) and of the CD to earth unbalance (v). There are no other changes within the core.

Rule (3). Cross Pairs. The operator (..X) changes the sign of the phantom to earth unbalance and interchanges the AB to phantom (α) and CD to phantom (β) interference characteristics, as well as the AB to earth (u) and the CD to earth (v) unbalances. There are no other changes within the core.

Rule (4). Any other type of cross will be a combination of any two of the types dealt with in (1), (2) and (3) or of them all; rules (1), (2) and (3) will accordingly be successively applied, care being taken always to apply (1) or (2), or (1) and (2) before applying (3).

Calculation of Residual Unbalances and Interference Characteristics.—The residual unbalances and interference characteristics for two lengths of cable joined together will depend not only upon the normal unbalances and interference characteristics of the individual lengths, but also upon the manner in which the wires are connected together. The calculation of the residual unbalances and interference characteristics for a section of cable composed of two cable lengths, each with definite unbalances and interference characteristics, joined together in any of the eight possible ways is obviously the essence of capacity balancing, and will now be considered.

If two cores of cable are joined together straight, the residual unbalances and interference characteristics of the combination will be the algebraic sum of the relevant unbalances and interference characteristics of the individual cores. This will be obvious from considerations of the wire-to-wire and wire-to-earth capacities existing in the combined length. Thus with the usual notation, undashed letters referring to one length, dashed letters to the other length:—

(1). The combined capacities will be:—

$(w+w')$, $(x+x')$, $(y+y')$, $(z+z')$, $(a+a')$, $(b+b')$, $(c+c')$, $(d+d')$.

(2). The residual unbalances will be:—

$(w+w') - (x+x') = (p+p')$; $(z+z') - (y+y') = (q+q')$; $(w+w') - (z+z') = (r+r')$; $(x+x') - (y+y') = (s+s')$; $(a+a') - (b+b') = (u+u')$; $(c+c') - (d+d') = (v+v')$; $(a+a') + (b+b') - (c+c') - (d+d') = (f+f')$.

(3). The residual interference characteristics will be:—

$(\gamma + \gamma')$; $(\alpha + \alpha')$; $(\beta + \beta')$.

If two cores are joined together with any of the recognised types of cross, the residual unbalances and interference characteristics can be determined from an analysis similar to that given above for two cores joined together straight. It is recommended that this be done for each of the various modes of connection between two cores. Examination of the results will show that irrespective of which of the regular modes of connection of two cores is adopted, their unbalances and interference characteristics will combine in such a manner that the residuals of the combined cores will be the algebraic sum of the relevant unbalances and interference characteristics respectively of the individual cores; the normal or straight values being considered for the straight length, the transformed or " referred " values being the relevant ones for the crossed length.

The following rule has been deduced with the object of rendering the determination of residual unbalances and interference characteristics in practice a perfectly systematic process; thus:—

Rule (5). To determine the residual unbalances and interference characteristics for the combination of two cores ABCD and A′B′C′D′, jointed together in any of the recognised modes, proceed thus:—

(i) Write down the normal unbalances and interference characteristics of the core A′B′C′D′.

(ii) Operate upon the unbalances and interference characteristics of the core ABCD with the operator expressing the cross applied to the core ABCD prior to jointing it to the core A′B′C′D′, *i.e.*, write down the unbalances and interference characteristics of the core ABCD referred to its crossed end.

(iii) Add the relevant unbalances and interference characteristics algebraically. The result will be the residual unbalances and interference characteristics of the combination.

From the mode of their derivation, it will be obvious that the residual unbalances and interference characteristics so obtained will be the normal values of the combined section at the free end of that length which has been regarded as straight. This is more simply expressed in the statement: " The calculated residual unbalances and interference characteristics refer to the straight length of cable."

Example (1)—Symbolical.

A′B′C′D′ (. . .)	γ'	α	β'	u'	v'	f'
ABCD (XXX)	γ	$-\beta$	$-\alpha$	$-v$	$-u$	$-f$
Residual, referred to length A′B′C′D′	$(\gamma'+\gamma)$	$(\alpha'-\beta)$	$(\beta'-\alpha)$	$(u'-v)$	$(v'-u)$	$(f'-f)$

Example (2)—Numerical.

	γ	α	β	u	v	f
A′B′C′D′ (. . .)	+ 10	+ 45	− 30	− 60	+ 50	− 100
ABCD (. . .)	− 5	− 20	+ 30	+ 40	− 75	− 120
ABCD (XXX)	− 5	− 30	+ 20	+ 75	− 40	+ 120
Residual, referred to length A′B′C′D′	+ 5	+ 15	− 10	+ 15	+ 10	+ 20

In the example given above the core A′B′C′D′ is regarded for the purposes of the calculation as the straight core. The residuals accordingly refer to that core. If for any reason it is desired that the residuals refer to the core ABCD, then it will be regarded as the straight core, the mode of connection of the cores being interpreted as an appropriate crossing operation performed upon the wires of core A′B′C′D′. In these circumstances the referred unbalances and interference characteristics of the core A′B′C′D′ will be added algebraically to the normal unbalances and interference characteristics of the core ABCD, the result being the normal residuals for the combined section, referred to the core ABCD. Generally for the connection of two cores, ABCD and A′B′C′D′, if (***) represents the cross applied to the wires of the core ABCD before connection to the wires of the core A′B′C′D′, then the appropriate crossing operation to be performed upon the wires of the core A′B′C′D′ before connection to the wires of the core ABCD, in order to secure the same result, will be written $(\overline{***})$. It will be obvious from what has previously been stated that $(\overline{***})$ is identically the same as (***) excepting in the two cases where $(\overline{X.X}) \equiv (.XX)$ and $(\overline{.XX}) = (X.X)$.

Referring Residual Unbalances and Interference Characteristics from one end of a Combined Length to the other.

From the foregoing explanation, but perhaps more readily from an examination of the capacity system of a combined core, consisting of two cores jointed together, it will be seen that the normal unbalances and interference characteristics of the combinations as determined at one end will, in the general case, be different from those of the remote end. They can be separately calculated for each end in the manner already indicated, provided the values for each length are known. In some cases, however, and particularly when the combined length consists of a number of jointed cores, it is necessary to refer the residual for the whole length from one end of the section to the other, without reference to the values of the individual lengths. The conversion may be readily effected by means of the following rule, which affords a striking example of the utility of Transformation Operators. Thus:—

Rule (6). To refer the residual capacity unbalances and interference charcateristics from one point (K) of a cable section to another point (L), through a number of intermediate crossed joints, proceed as follows:—

Write down the residuals referred to the joint K and operate upon them successively by means of the operators which express the crosses at each of the intermediate joints between K and L. The operators used must in every case refer to the system of crosses on that side of the joint which is nearer the end K to which the residuals initially referred. Further, the operating must commence with the operator for the joint nearest to K, proceeding from thence in order to L, and care being taken in operating with any particular operator to perform the wire crosses before the pair crosses.

In reference to the last sentence, it is pointed out that a series of operations performed in a given order upon a set of unbalance and interference characteristics will, in the general case, produce a different result if performed in some other order. Thus, in the following, the same series of crosses is employed, but the order of their occurrence in the second example is different from that of the first:—

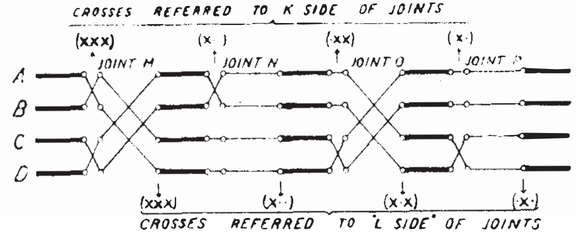

CROSSES REFERRED TO "K SIDE" OF JOINTS
(xxx)
(x·)
(·xx)
(x·)
JOINT M
JOINT N
JOINT O
JOINT P
A
B
C
D
K
L
(xxx)
(x··)
(x·x)
(·x·)
CROSSES REFERRED TO "L SIDE" OF JOINTS

FIGURE (9)

Example (1). Fig. **9** refers.

ABCD (XXX) (X..) (.XX) (.X.)
≡ DCBA (X..) (.XX) (.X.)
≡ CDBA (.XX) (.X.)
≡ ABCD (.X.)
≡ ABDC
≡ ABCD (.X.)

and consequently:—

$(\gamma,\ \alpha,\ \beta,\ u,\ v,\ f)$ (XXX) (X..) (.XX) (.X.)
$\equiv (\gamma,\ \alpha,\ \beta,\ u,\ v,\ f)$ (.X.)
$\equiv (-\gamma,\ \alpha,\ -\beta,\ u,\ -v,\ f.)$

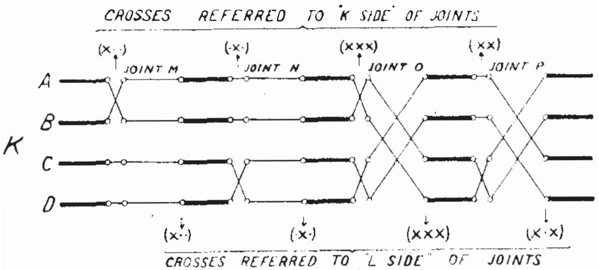

CROSSES REFERRED TO "K SIDE" OF JOINTS
(x··)
(·x·)
(xxx)
(·xx)
JOINT M
JOINT N
JOINT O
JOINT P
A
B
C
D
K
L
(x··)
(·x·)
(xxx)
(x·x)
CROSSES REFERRED TO "L SIDE" OF JOINTS

FIGURE (10)

Example (2). Fig. **10** refers.

ABCD (X..) (.X.) (XXX) (.XX)
≡ BACD (.X.) (XXX) (.XX)
≡ BADC (XXX) (.XX)
≡ CDAB (.XX)
≡ BACD
≡ ABCD (X..)

Use of Operators in Selecting and Scheduling for the Rebalancing of Loading Coil Sections of Cable.

The maintenance of balanced trunk cables sometimes involves the replacement of a length (F), which may be faulty, by a new length (N) of cable. The following methods are employed depending upon the circumstances of the case :—

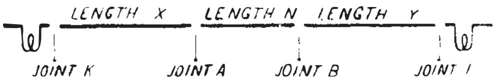


FIGURE (11)

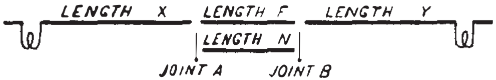


FIGURE (12)

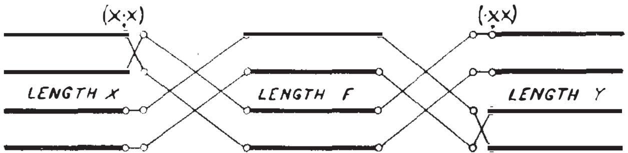


FIGURE (13)

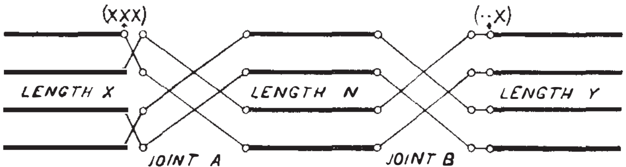


FIGURE (14)

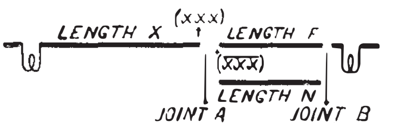


FIGURE (15)

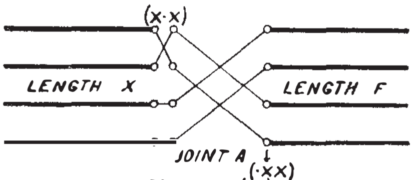


FIGURE (16)

(1) *General Method.*—Fig. **11** refers. N is the new or replacing length of cable. X and Y are jointed cable lengths on either side of N to which N is required to be connected at the joints A and B. The procedure is as follows :—

(i) Test length X from joint A, after disconnecting the loading coil at joint K.
(ii) Test length Y from joint B, after disconnecting the loading coil at joint L.
(iii) Test length N from either joint A or joint B.
(iv) Make a triple selection from the results of (1), (ii) and (iii) for best balance. If the values so obtained for the loading coil section exceed those specified it will be necessary to open a cable joint either in length X (or in length Y); test the separate portions of that length and make a Quadruple Selection. The test results for one of the portions of length X (or of length Y) will generally require to be referred, through all the crossed joints in that portion, before the jointing schedules can be prepared from the Quadruple Selection.

(2) *Substitution Method.*—Fig. **12** refers. F is the faulty or replaced length of cable. N is the new or replacing length of cable. X and Y are jointed cable lengths on either side of N to which N is required to be connected at the joints A and B. If the core unbalances of length N are similar in magnitude, type and class to those of length F, *i.e.*, if the core unbalances of length N exactly or approximately simulate those of length F, and if full particulars of the original joints at A and B are known, the procedure is as follows :—

(i) If the length X was crossed originally on to the length F with the system of crosses represented by (†††).
(ii) If the length Y was crossed originally on to the length F with the system of crosses represented by (‡‡‡).
(iii) If (***) represents the operator necessary to transform the unbalances and interference characteristics *of a core of length F to those of a core of length N*, *i.e.*, if (F) (***) ≡ N, then :—
(iv) Length X will require to be crossed on to the length N with the system represented by (†††)(***).
(v) Length Y will require to be crossed on to the length N with the system represented by (‡‡‡)(***).

Example, Figs. (13) and (14) apply. If for particular cores, (†††) ≡ (X.X); (‡‡‡) ≡ (.XX), and (***) ≡ (X..), then for such cores:—

Joint A ≡ (†††)(***) ≡ (X.X)(X...) ≡ (XXX) on the wires of X.

Joint B ≡ (‡‡‡)(***) ≡ (.XX)(X..) ≡ (..X) on the wires of Y.

The operators must of course be used in the order stated for reasons previously given.

(3) *Deduced Joint Method.*—Fig. (15) refers. F is the faulty or replaced length of cable, N is the new or replacing length of cable. X is a jointed cable length on one side of N, to which N is required to be connected at the Joint A. If in addition to the unbalances of the cores of F, full particulars of the original joint at A as well as the original residual core unbalances of the complete length (X and F jointed together) are known, the procedure is as follows:—

(i) If R represents the original residual unbalances of a core of the complete length (X and F jointed together) referred to Joint B.

(ii) If r represents the unbalances of a core of the length F.

(iii) If the core of length X was crossed originally on to the core of length F with the system of crosses represented by (†††), then:—

(iv) $(R - r)$ $\overline{(\dagger\dagger\dagger)}$ represents the normal residual unbalances of the core of length X where $(R - r)$ represents the algebraic subtraction of r from R and $\overline{(\dagger\dagger\dagger)}$ is the operator which represents the original cross on length F at the joint A.

(v) Select the residual unbalances $(R - r)$ $\overline{(\dagger\dagger\dagger)}$ of the length X (at joint A) and the unbalances of the length N for the new joint at A.

Example, Fig. (16) refers.

If $R \equiv +10+30+10-50-20-100$,

$r \equiv +20-70+90+100-130+250$,

and $(\dagger\dagger\dagger) \equiv (X.X)$;

Then $(R-r) \equiv -10+100-80-150+110-350$.

and

$(R-r)\ \overline{(X.X)} \equiv (R-r)\ (.XX)$,

$\equiv +10+80+100-110-150+350$.

The author is much indebted to Mr. L. C. Voss for the preparation of the illustrations.

TABLE No. 1.

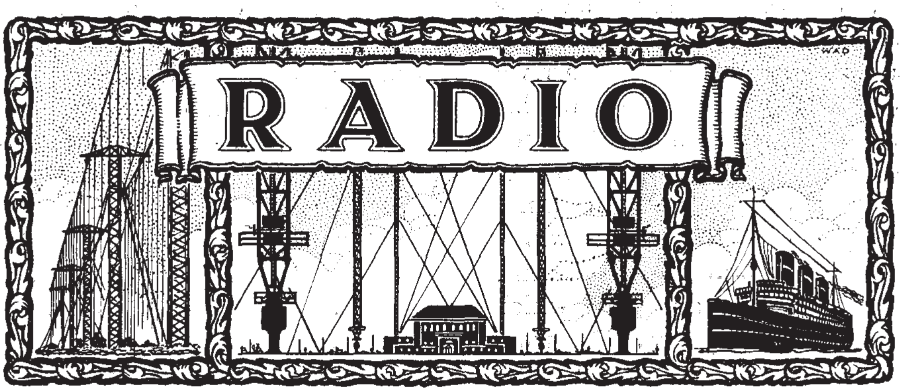
TRANSFORMATIONS EFFECTED BY THE CROSSING OF THE WIRES OF A CORE FOR WITHIN-CORE CAPACITY BALANCING PURPOSES.

Type of Cross.	(. . .)	(X..)	(.X.)	(..X)	(XX.)	(X.X)	(.XX)	(XXX)
Arrangement of wires and of associated capacities.	A Z W D C Y X B ABCD	B Y X D C Z W A BACD	A W Z C D X Y B ABDC	C X W B A Y Z D CD AB	B X Y C D W Z A BA DC	C W X A B Z Y D CD BA	D Y Z B A X W C DC AB	D Z Y A B W X C DC BA
Direct wire to wire capacity of other pair.	w x y z	x w z y	z y x w	w z y x	y z w x	x y z w	z w x y	y x w z
Wire to Earth capacity.	a b c d	b a c d	a b d c	c d a b	b a d c	c d b a	d c a b	d c b a
Wire to wire of other pair, capacity unbalance.	p q r s	$-p$ $-q$ s r	q p $-r$ $-s$	r s p q	$-q$ $-p$ $-s$ $-r$	s r $-p$ $-q$	$-r$ $-s$ q p	$-s$ $-r$ $-q$ $-p$
AB to Earth capacity unbalance.	u	$-u$	u	v	$-u$	v	$-v$	$-v$
CD to Earth capacity unbalance.	v	v	$-v$	u	$-v$	$-u$	u	$-u$
Phantom to Earth capacity unbalance.	f	f	f	$-f$	f	$-f$	$-f$	$-f$
AB to CD interference characteristic.	γ	$-\gamma$	$-\gamma$	γ	γ	$-\gamma$	$-\gamma$	γ
AB to Phantom interference characteristic.	α	$-\alpha$	α	β	$-\alpha$	β	$-\beta$	$-\beta$
CD to Phantom interference characteristic.	β	β	$-\beta$	α	$-\beta$	$-\alpha$	α	$-\alpha$

TABLE No. 2.

DEFINITIONS OF TRANSFORMATION OPERATORS FOR WITHIN-CORE CAPACITY UNBALANCES AND CAPACITY INTERFERENCE CHARACTERISTICS.

OPERATOR.	Capacity unbalances.							Capacity interference characteristics.		
	Wire to wire.				Wire to Earth.					
(Normal Value) (. . .) … … …	p	q	r	s	u	v	f	γ	α	β
(do. do.) (X..) … … …	$-p$	$-q$	s	r	$-u$	v	f	$-\gamma$	$-\alpha$	β
(do. do.) (.X.) … … …	q	p	$-r$	$-s$	u	$-v$	f	$-\gamma$	α	$-\beta$
(do. do.) (..X) … … …	r	s	p	q	v	u	$-f$	γ	β	α
(do. do.) (XX.) … … …	$-q$	$-p$	$-s$	$-r$	$-u$	$-v$	f	γ	$-\alpha$	$-\beta$
(do. do.) (X.X) … … …	s	r	$-p$	$-q$	v	$-u$	$-f$	$-\gamma$	β	$-\alpha$
(do. do.) (.XX) … … …	$-r$	$-s$	q	p	$-v$	u	$-f$	$-\gamma$	$-\beta$	α
(do. do.) (XXX) … … …	$-s$	$-r$	$-q$	$-p$	$-v$	$-u$	$-f$	γ	$-\beta$	$-\alpha$



ATMOSPHERICS.

[*An extract from Lt.-Col. A. G. Lee's chairman's address to the Wireless Section, I.E.E., on the 2nd November, published with the permission of the Institution.*]

THE question of "atmospherics" is one which is of interest in all wireless communications. The subject is a very wide one and I have preferred to confine myself, so far as the practical aspects are concerned, to one particular problem upon which we have been engaged, that of transatlantic telephony, and to draw upon that problem for practical illustrations.

SECTION I.

NATURE OF ATMOSPHERICS.

Our information on the nature of atmospherics is obtained from a series of valuable reports by Appleton, Watson Watt, and Herd.* These investigators, using the cathode-ray oscillograph, were able to obtain pictures of the potential induced by atmospherics in an antenna. Generalizing from their reports, one may say that an atmospheric is either of aperiodic or quasi-periodic form, it has a peak voltage of the order of 0.1 volt per metre, and has a duration of the order of 0.003 sec. Considerable variations from these figures occur and, in particular, atmospherics were observed which had a fine ripple structure superposed upon the main wave-form.

DISTRIBUTION OF ATMOSPHERICS IN AZIMUTH.

The cathode-ray direction finder, kindly lent by the Radio Research Board, has been used at Cupar, Fife, to determine the direction of arrival of atmospherics at that place. The apparatus consists of two frame aerials set at right angles and connected through similar amplifiers to the four plates of the cathode-ray oscillograph. The beam of light in the oscillograph acts like a pointer to indicate the magnitude and direction of the fields set up by an individual atmospheric. An observer notes the angle and the magnitude of the flash caused by an atmospheric, and calls out the figures to an assistant who writes them down. Samples of the results of some observations of this kind at Cupar are shown in Fig. 1. The instrument used gave an ambiguity of 180° in the direction of arrival of atmospherics, but this caused no real difficulty because the approximate direction was known by the behaviour of the directive receiving arrangements normally in use at the station at Cupar. The crosses in the diagram indicate comparatively light atmospherics, while the circles indicate heavy atmospherics. The diagram is a composite target diagram of all the observations made during the months of July, August and September, 1927.

It is convenient to refer the direction of arrival of atmospherics to the direction of the signal, with its directive receiving arrangements, in lieu of the more usual use of the geographical direction. In this particular case the signal to be received arrives from a direction 11° north of west, and the direction of arrival of atmospherics is given with reference to this direction as a base line. The angle between 140° and 260° is found to be the subject of attack from atmospherics at different times during the working period of the circuit, which is open for traffic from midday to 11 p.m., whilst the angle between 310° and 130° which includes the signal is relatively very free from atmospherics. The worst directions are between 170° and 230°.

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* *Proceedings of the Royal Society, A,* 1923, *Vol.* 103, *p.* 84; *ibid.,* 1926, *Vol.* 111, *p.* 615; *ibid.,* 1926, *Vol.* 111, *p.* 654.

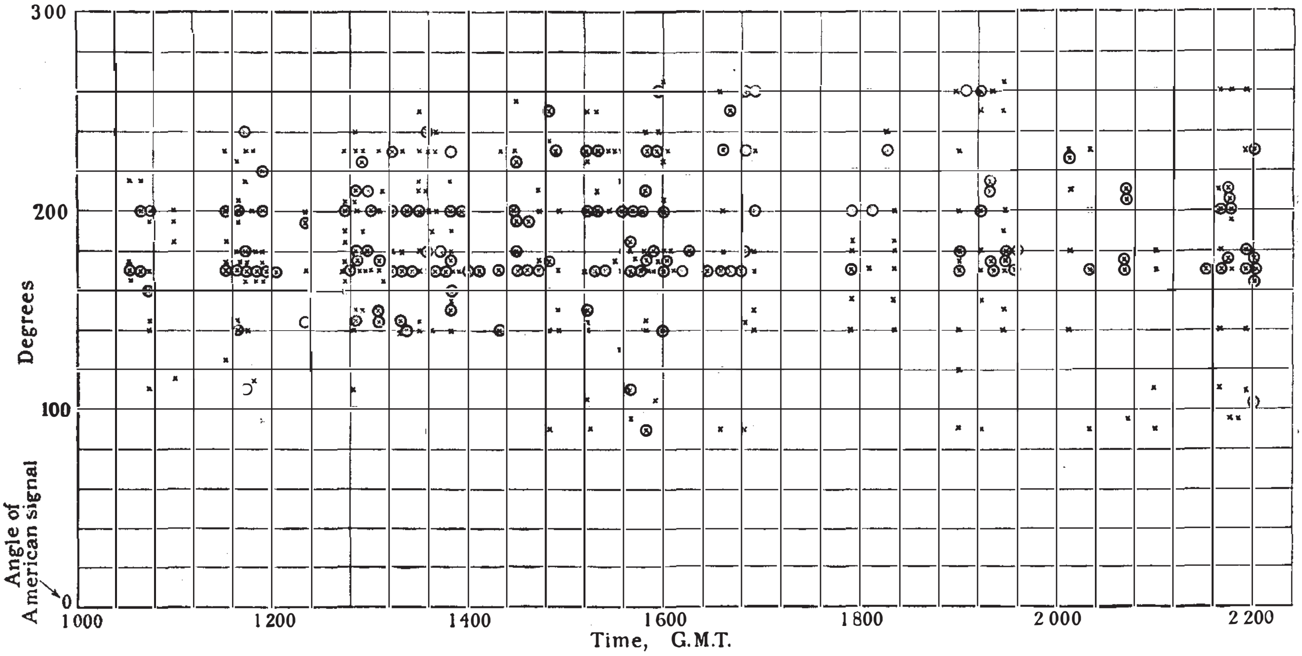

FIG. 1.—DISTRIBUTION OF ATMOSPHERICS AT CUPAR DURING MONTHS OF JULY, AUGUST AND SEPTEMBER, 1927.

DISTRIBUTION OF ATMOSPHERICS WITH LATITUDE.

Measurements of the strength of atmospherics, carried out in connection with the preliminary work on transatlantic telephony, were made at Stranraer, Cupar, Ellon and Thurso, in addition to those normally made each week at Wroughton in the south of England. These measurements showed that the atmospherics were generally weaker in Scotland than in the south of England. In addition, the Scottish locations are slightly nearer America and the signal strength obtained there was greater than that at Wroughton, so that the signal noise ratio at Cupar, near Dundee, is nearly 4 times better than that obtained at Wroughton, whilst at Thurso in the extreme north of Scotland it is nearly 8 times better. It was finally decided to locate the receiving station at Cupar on account of its proximity to the underground cable system.

THE SPECTRUM OF ATMOSPHERICS.

Lord Rayleigh showed many years ago that an aperiodic pulse can be represented by the Fourier integral of an infinite spectrum of continuous sinusoidal components. If we assume that the atmospheric is wholly represented by an aperiodic or quasi-periodic disturbance, then it follows that the effect of an atmospheric on a wireless circuit is such that if the latter is designed to admit a signal with just sufficient of its side bands due to modulation to render it intelligible, the circuit will also admit the sinusoidal components of the atmospheric pulse which lie within the resonance curve of the apparatus, and it is impossible to exclude them by processes dependent upon selectivity. This theory therefore removes from the discussion the numerous atmospheric eliminators which have been patented in the past, and enables one to concentrate on the design of a straightforward filter circuit which will allow of the reception of the signal with a minimum exposure to atmospheric attack.

Before commencement of the transatlantic telephony service a large series of measurements was made, extending over several years, of the strength of signals and atmospherics at different times of the day. The atmospherics were measured on a receiver with a band width of 2,500 cycles, so that, in effect, a measurement was made of the attack of the spectrum on a receiver with the band width necessary for telephonic communication. The measurements were made at different frequencies and, as a result, it was concluded that the optimum wavelength for transatlantic communication of this particular kind lay between 5,000 and 6,000 metres, having regard to the ratio of signal strength to atmospherics at different times of the day. The problem is to some extent a commercial one as well as technical, as it involves the production of the best circuit conditions for the time of day when the commercial use is greatest.

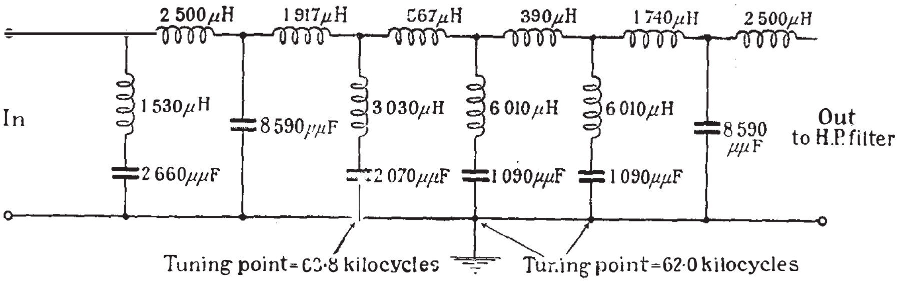

FIG. 2.—HIGH FREQUENCY LOW PASS FILTER.

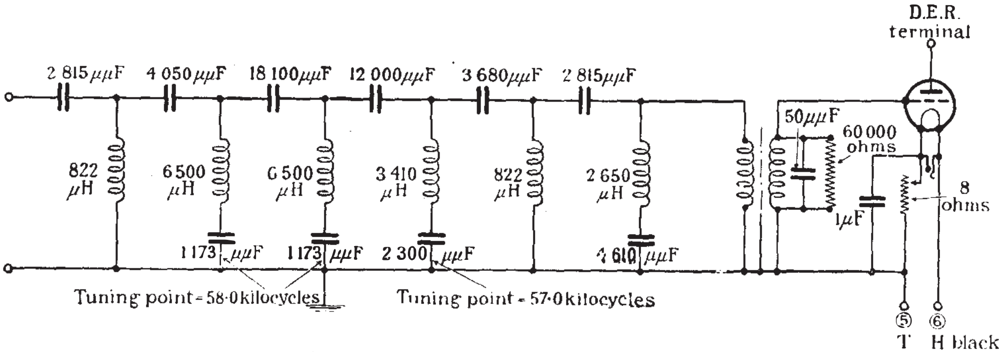

FIG. 3.—HIGH FREQUENCY HIGH PASS FILTER.

SECTION 2.

THE RECEIVER PROBLEM.

It has been pointed out in the previous Section that a receiver should be designed to admit only just sufficient of the signal and its modulation products to ensure intelligibility, and it will then possess its maximum defence against atmospherics. Any process depending upon selectivity, which still further reduces atmospherics, will also reduce the intelligibility.

In the problem under discussion—the reception of transatlantic telephony—the signal consists of a single side band, the carrier 58.5 kilocycles, and the other side band not being transmitted. The side band is also subjected to a certain amount of filtering before transmission from the sending antenna, and we are left to deal with high frequencies corresponding, after detection, to frequencies in the voice range extending from 400 to 2,800 cycles. It has been found that the frequencies below 400 and above 2,800 are not essential to intelligibility, though they add to the naturalness of the speech. The frequencies below 400 demand a relatively much larger amount of energy than those above 400, and hence their omission allows of the power available being used for the frequencies which carry the intelligibility, without making so much demand on power. Further, the cutting off the edges of the band in this manner reduces the exposure to atmospherics at the receiving end. The suppression of the carrier and one side band also saves a large amount of energy and at the same time reduces the exposure to atmospherics. It is necessary, however, to reintroduce the carrier at the receiving end before the detector in order to render the single side band intelligible.*

The receiver to be described is one which was designed by the Post Office. It is of the single detection type and in that respect differs from the American receiver which employs the double detection principle. There is no essential difference in the results, but as the receiver is one in which nearly all the filtering is effected at 60 kilocycles it may form an interesting example of what can be done at that frequency. It may as well be admitted at once that the design of filters for high frequencies is difficult, and assistance is obtained in cutting off the edges of the band sharply by the employment of low-frequency filters at a later stage in the receiver.

The first condition to be met was the design of a filter for insertion before the first amplifying valve. Although the valve has a so-called straight characteristic, it will perform the function of modulation if the largest of the unwanted signals and atmospheric components are not removed before passing into the amplifying system.

This filter consists of a low-pass and a high-pass filter in tandem, giving the equivalent of a band-pass filter. The circuit conditions of the low-pass filter are given in Fig. **2** and that of the high-pass in Fig. **3**, whilst Fig. **4** shows the results obtained by the filter. This system was chosen because the values of the components for the normal type of band-pass filter for a width of 3,000 cycles and at a midband frequency of 60 kilocycles were awkward to obtain and maintain. The coils were made of stranded wire wound into pancake form and each shielded in a copper box. The inductance of each coil was measured at 60 kilocycles and adjusted by unwinding turns. The final adjustment of the condensers was performed by removing plates from small fixed air condensers. The low-pass unit consists of two ordinary sections designed to cut off at 61.8 kilocycles, two sections with a cut off at 61.5 kilocycles and theoretical zero impedance point at 62 kilocycles, and another section with a cut off at 61.8 kilocycles and tuning point at 63.8 kilocycles. Both filters were designed for input and output impedances of 600 ohms. This panel is followed by the high-pass filter of similar construction to the above, the ordinary sections cutting off at 58.2 kilocycles, the tuned sections being resonant at 58 kilocycles and 57 kilocycles. The filter terminates in a valve input transformer stepping up from 600 ohms to 60,000 ohms on the grid of the first valve. As the filters are only used on a small portion of their pass frequencies the imput impedance is about 1,100 ohms, but this is rectified by using a step-up transformer in front of the filter. It will be seen by inspection of Fig. **4** that the cut-off at 500 cycles on either side of the band is about 40 transmission units (T.U.).

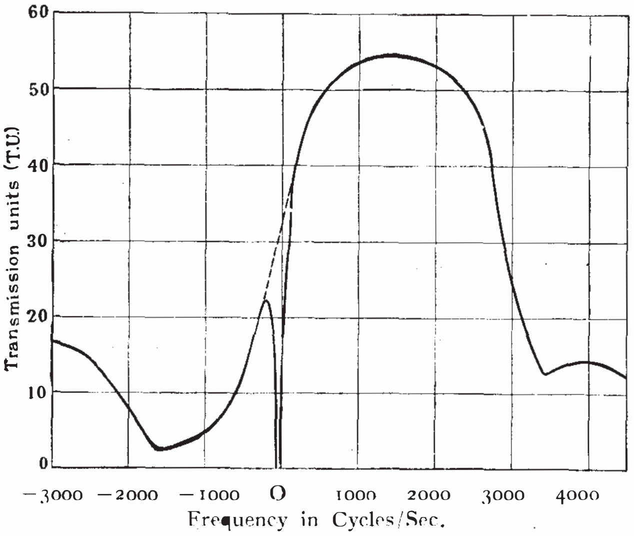

FIG. **4**.—FREQUENCY CHARACTERISTICS OF HIGH FREQUENCY FILTER.

The filter is followed by two amplifying stages which have band filters consisting of two simple circuits coupled together, giving the well-known double-humped curve. The filter curve has rounded corners and the effect of the double-humped curves following the filter is to lift up the rounded corners to a more or less square form. Further amplifying stages, having potentiometer control of the amplification, follow the band filters, then the local carrier is inserted before the detector, and following the detector is a low-frequency low-pass filter and a high-pass filter and further low-frequency amplification with potentiometer control.

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* *H. W. Nicholls*: "*Transoceanic Wireless Telephony,*" *Journal I.E.E.*, 1923, *Vol.* 61, *p.* 812.

The overall frequency characteristics of the complete receiver including both high- and low-frequency filters is given in Fig. **5**. It will be seen that the curve approximates to a rectangle with the top nearly, but not quite, flat.

The available overall amplification is about 100 T.U. and an output of + 15 T.U. above one milliwatt can be taken without distortion.

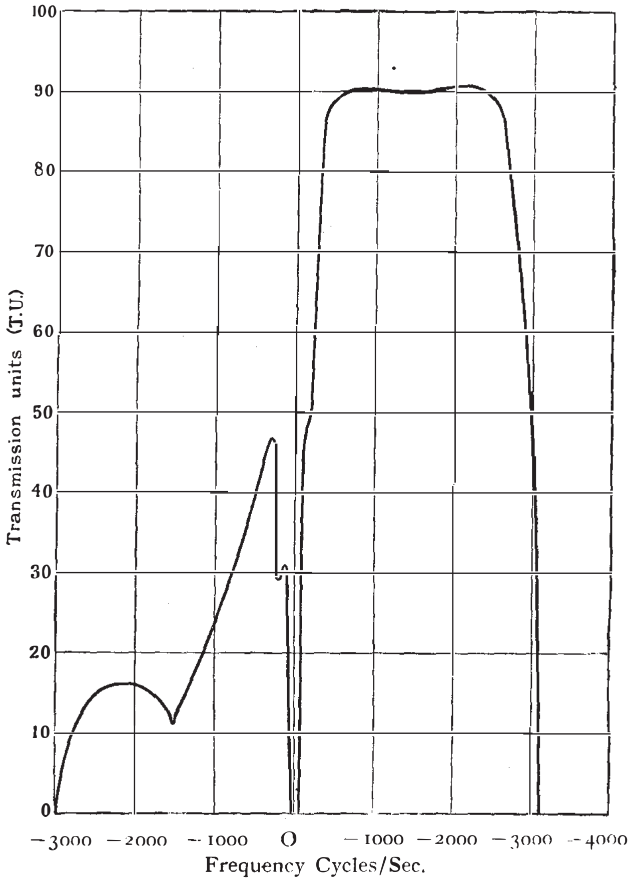

Fig. 5.—Overall Frequency Characteristic of Complete Receiver.

SECTION 3.

Directive Reception with Wave Antenna.

Having done all that is possible at the receiver to reduce the exposure to atmospherics, the next step is the development of directive reception. Seeing that atmospherics may arrive from all possible directions, we can reduce the exposure by employing a directive system of reception which allows of the signal being received, but which is relatively insensitive to signals or atmospherics received from other directions. We have seen in Section 1 that the transatlantic service is favoured by most of the atmospherics coming from the sector opposite to that from which the signal arrives.

The early experiments on the wave antenna* in this country having proved extremely favourable it was decided to adopt that system for the antenna at Cupar.

The wave antenna, as used, consists of two parallel wires carried on ordinary telegraph poles a distance of just over 3 miles, which is one wave-length for this particular communication. The antenna picks up the horizontal component of the electric field passing over it, which gives rise, by a process of summation, to a current in the wires which is greatest at the end opposite to that from which the signal arrives. A transformer is placed at this point to transfer the current to the two wires, considered as a transmission line, which carry the current back to the near end where the receiver is connected. At the receiver a certain amount of the wire-to-earth current can be combined with the current from the far end of the antenna to produce zero reception at a selected angle in the back sector, a process known as compensation. One such system constitutes a wave antenna, and combinations of such systems, spaced apart at a distance of 0.62 wave-length, are used to give additional directivity. The wave antennæ are properly terminated at each end to avoid reflections, and the currents are carried from the wave antennæ to the receiving hut by means of transmission lines, precautions being taken to avoid cross-talk between the various lines.

It will be realized that the directive properties of the wave antenna, and the amount of signal, depend to a large degree on the tilt of the electric waves, as it is designed to utilize the horizontal component of the electric field. So far, we have built three systems of wave antennæ in this country, at Chedzoy (Somerset), Wroughton (Wilts) and Cupar (Fife), and the tilts obtained at these places were 0.1°, 0.7° and

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* *Beverage, Rice, and Kellogg. Journal of the American I.E.E.*, 1923, *Vol.* 42, *p.* 215.

1.0° respectively, as against values of between 2° and 3° which were obtained on the wave antennæ built in America. The differences are probably due to the nature of the soil. At Chedzoy the soil is swampy, at Wroughton the ground-level is high with a chalk subsoil close to the surface, and at Cupar the subsoil is sandstone. The differences between the tilts in this country and America may also be accounted for by possibly moister conditions of the soil here. This lack of tilt leads to the vertical effects of the antennæ becoming large relatively to the desired horizontal effects and tends to reduce the directivity of the system. That is to say the antenna may be regarded as a rather long antenna which picks up the field by virtue of its height above ground, whereas the horizontal effect is not directly dependent upon the height above ground. In the normal wave antenna on suitable terrain the horizontal effects preponderate and the vertical effects may be neglected in comparison. Also, undulations in the ground tend to have a bad effect on a system of small tilt and it becomes difficult to build several antennæ with the same electrical results, leading again to loss of directivity when the antennæ are combined. Fig. **6** shows the calculated and observed results for the wave antennæ at Cupar. The curve marked A is the calculated result if the antenna were perfect, that is, with the vertical and therefore non-directive elements negligible compared with the horizontal effects. Curve B shows the calculated results combining the horizontal and vertical effects actually present, and small squares and circles near this curve represent actual measurements on signals arriving from the directions indicated. These observations check moderately well with the calculated curve, but it will be seen that the two antennæ which have so far been completed are not exactly alike, which renders their combination into a still more refined directive system less perfect than it should be. Although built with extreme care, the ground conditions in the two cases are not identical, and it appears difficult to secure this in the ordinary type of country in England or Scotland. In countries with more highly resistive ground conditions the disturbing vertical effects are of much less importance and much better results should be obtainable. This statement does not exclude the fact that excellent results are obtained at Cupar with these wave antennæ, the improvement over ordinary frame reception being most marked. Experiments are, however, being made at the present time with other systems of directive reception which do not depend essentially upon the tilt of the wave front, and these systems are described later in this address.

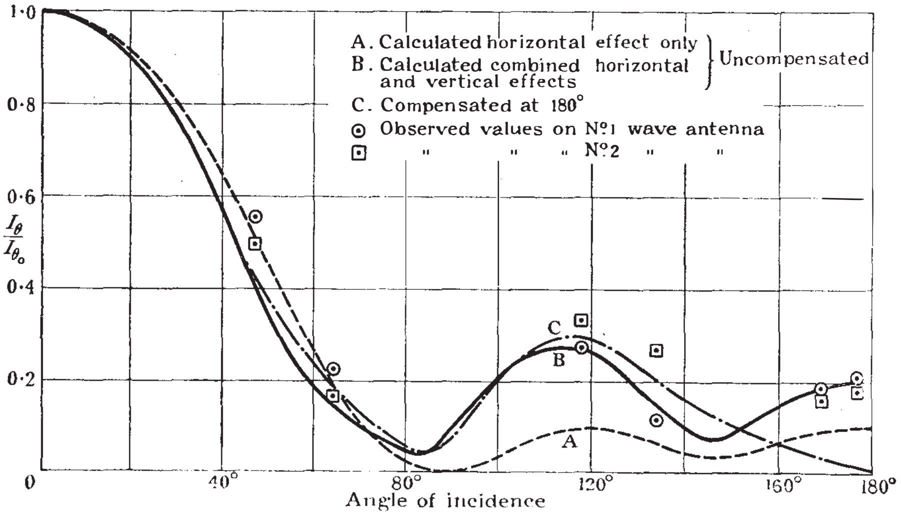

Fig. **6**.—Directive Curves for One Wave Antenna at Cupar.

SECTION 4.

ANTENNA ARRAYS.

Directive systems of transmission and reception depending upon the distribution of antenna systems in space with prearranged phase relations were invented in quite the early days of wireless.

S. G. Brown* was, as far as is known, the first to suggest spaced antennæ to obtain directivity. Bellini† in 1914 extended the spacing system, giving a large number of diagrams by which very sharp directivity could be obtained. Foster‡ has also extended the series of diagrams still further to collections of antennæ which he refers to as antenna arrays.

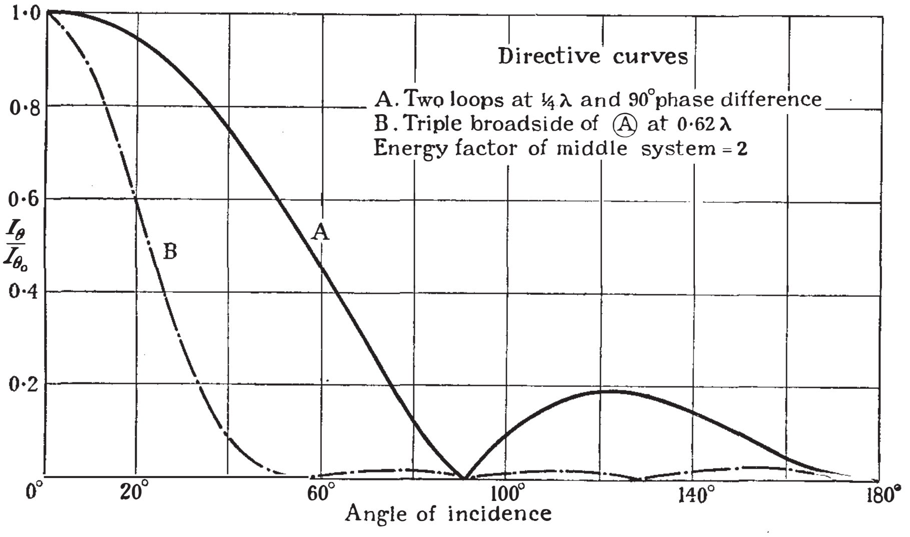

FIG. 7.—DIRECTIVE CURVES.

Beverage, Rice and Kellogg§ have given a very extensive bibliography of this subject in connection with their paper on the wave antenna. Reference may perhaps be made to these papers for fuller information on the subject. The Marconi antennæ used for the beam stations are amongst modern examples of antenna arrays.

For the purpose of the present paper it is proposed to refer to two only of the many possible diagrams in the papers referred to, because these two diagrams stand out prominently as representing the maximum amount of directivity to be obtained with the simplest possible arrangements.

The first diagram represents the result of spacing two vertical aerials ¼ wave-length apart and combining them with a phase difference of 90°, the result being nearly a cardioid diagram. This combination is extremely useful for producing zero reception at the angle opposite the signal. This particular diagram will be referred to as the " staggered " arrangement. The other diagram, known as the broadside arrangement, is the result of combining with equal phases two vertical antennæ at a distance of 0.6 wave-length apart on a line at right angles to the signal, this distance apart being chosen as giving the maximum reduction of area from the original circle diagram of each vertical aerial. These two diagrams have been selected from a large number of possible combinations as giving very marked directivity, and the further combinations or arrays which are made utilize these directive properties in a simple fashion.

It has been pointed out by Foster that using any type of directive system as a unit which is distributed in phase and space, we can calculate the directive diagram for a system of vertical aerials so distributed, and the product of the unit diagram by the directive diagram of the array of vertical aerials gives the result of making an array of the particular type of directive system.

With the broadside combination of two

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* *British Patent No.* 14449/1899.

† *Electrician*, 1914, *Vol.* 74, *p.* 352.

‡ *Bell System Technical Journal*, 1926, *Vol.* 5, *p.* 292.

§ *Loc. cit.*

antenna systems the reduction of area is very marked. So large is this reduction that where a number of antennæ are to be combined it is better to combine them in pairs and then to combine the pairs again in pairs rather than employ the plain paralleling of the ordinary antenna array.

In the antenna systems at Cupar the ratio of energy supplied by the middle antenna to that from the outside antennæ is adjustable to meet particular conditions of atmospheric distribution.

The Cupar system was designed to employ a broadside arrangement of three wave antennæ, but up to the present only two of these antennæ have been completed.

In view of the difficulty in regard to the small tilt of the wave front in this country, we are at present engaged on experiments with combinations of frames and vertical aerials, for which calculations indicate marked directive effects. Fig. 7 is the diagram for a triple broadside of staggered frames, using an energy factor of two for the middle system. The staggering proposed is ¼ wave-length with 90° phase displacement. This diagram gives results of a similar order to the triple broadside of wave antennæ. Fig. 8 employs as the unit a staggered combination of two cardioid arrangements, each consisting of a frame and vertical aerial, the cardioids being at ¼ wave-length separation. The diagram gives the result of a triple broadside of these units, again using an energy factor of two for the middle units. It will be seen that the diagram is nearly zero from 120° to 240°. The curve C in the same figure is the result of using an energy factor of 1.6 for the middle unit. Comparison of this curve with Fig. 1, giving the distribution of atmospherics at Cupar, shows that if it is possible to attain the correct combination of the several frames and vertical aerials very considerable improvement should be obtainable.

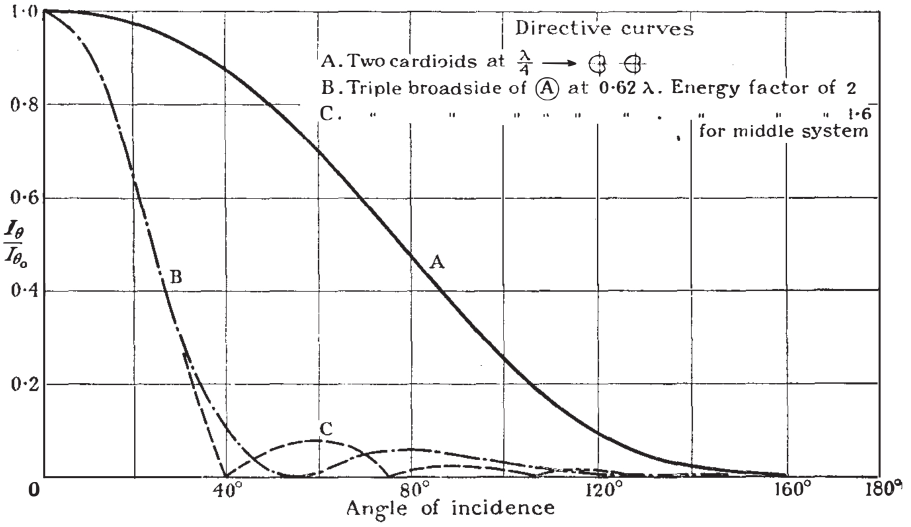

Fig. 8.—Directive Curves.

The success of such combinations depend, however, in very great care being exercised in making all the elements of the combination exactly alike. This process must cover not only the amplitude but also the phase at every frequency within the band of reception. Also for telephony reception there must be no undue attenuation of signals at the edges of the band owing to the tuning of the circuits being too sharp. The frames and verticals require either to be constructed with identical reactive and resistive components or to be combined with circuits which will produce the same effect of equalizing the phase and amplitude at all points in the frequency range.

PROPAGATION AROUND THE EARTH.

ALTHOUGH it is now well known to radio engineers that etheric waves of the order of 20,000 kilocycles per second can pass completely round the earth and still be received with normal apparatus, some examples of this phenomenon observed on the Beam installation working between this country and South Africa and India respectively may be of general interest.

The possibility of signals traversing the longer path between two stations and arriving with sufficient strength to affect the reception of signals directly received has been experimentally demonstrated by E. Quack, of Berlin, who has published records showing not only signals arriving by the longer path from America but also signals which have encircled the earth more than once.

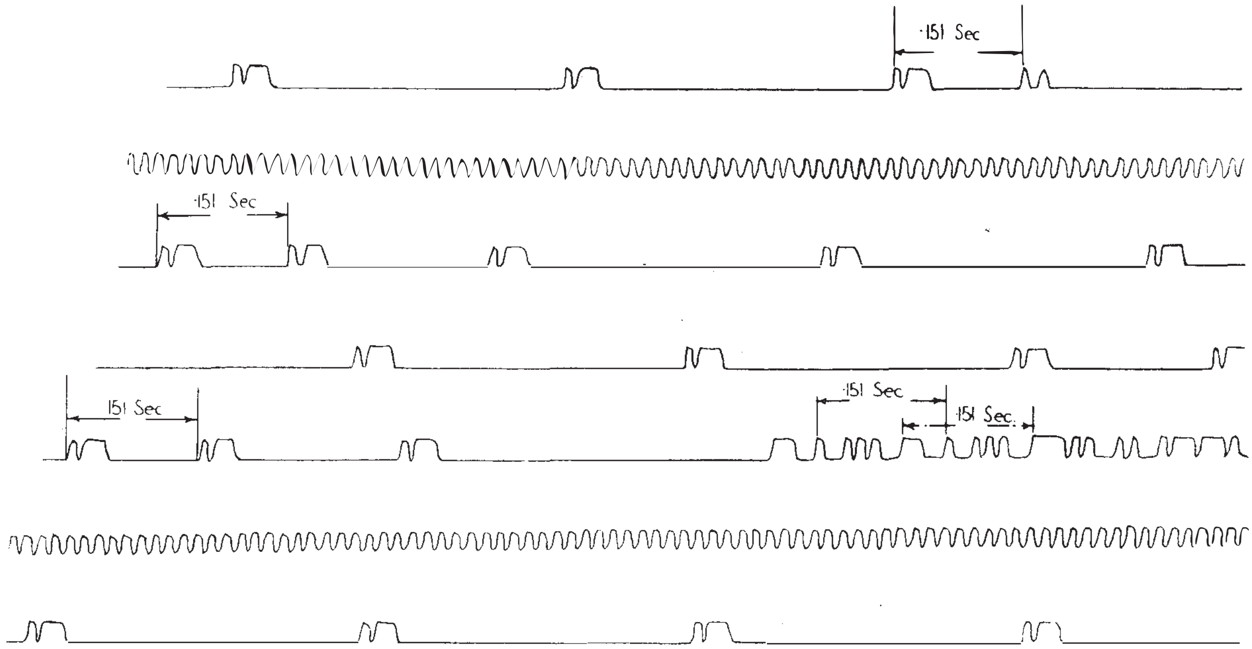

Fig. 1.

The records here illustrated were obtained not as a part of an investigation into this phenomena, but in an attempt to fix the cause of complaints of bad received signals which arose intermittently and at rare intervals on the South African Beam service.

On the Beam services both the transmitting and receiving stations are equipped with reflectors, the purpose of which, in the case of the former, is to conserve the propagation of the energy in the short path direction, and in the latter, to make the receptivity greatly more sensitive to waves arriving *via* this short path. Signals, therefore, which travel *via* the backward and longer path, are attenuated by the action of the transmitting system and upon arrival at the receiving station are received with much less sensitivity than waves arriving by the forward path.

It is interesting to note that none of the records so far obtained at Bridgwater from South Africa indicates the reception of signals arriving *via* the backward path.

In order to obtain slip which would act as a record of doubly received signals and at the same time allow of a computation of the path traversed by the secondary signal, it was arranged that slip should be punched up consisting in the main part of letters " A " spaced twenty centre holes apart: and that this slip should be sent at a checked speed of 150 words per minute. At this speed the blank space between the letters on the received tape would represent a time interval of one-third of a second, which interval was chosen as allowing of a clear record, if received, of signals either back path, once round, or twice round the earth.

The first slip so punched up was sent *via*

Klipheuval, the South African transmitting station of the system, and received at Bridgwater, the English receiving station, at 1758 on the 11th November. This slip yielded results illustrated in Fig. **1** on page 307, and clearly showed the intermittent presence of a second " A " amongst those directly corresponding to the transmitted slip. The interval between the two signals, which was constant in all the cases, was equal to .151 second; which clearly indicates that the wave, after making its primary record at the receiving station had then encircled the earth and arrived with sufficient energy to again make a record. This slip also illustrates the type of mutilation which can occur from double signals intermittently received, *e.g*, the extra dot after the word " Test," and the joining together of the dot dash of the letter " l " in the word slip.

Other slips obtained during the week ended 19th November yielded similar results, all the cases giving a double signal arising from the wave traversing the path around the earth, after being once received. The time interval, although constant for any one slip, varied each day, the difference being ascribed to the speed of sending not being accurately adjusted to 150 words per minute.

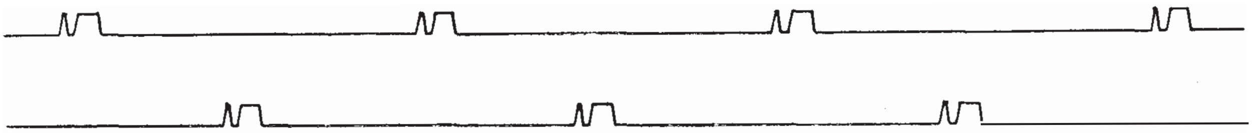

Fig. **2**.

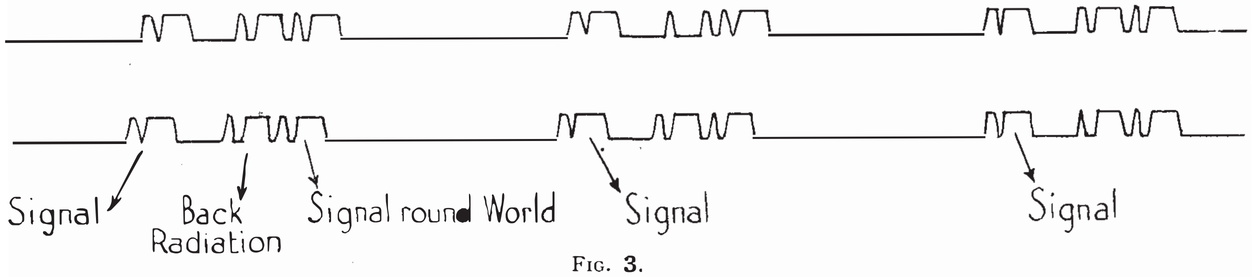

Fig. **3**.

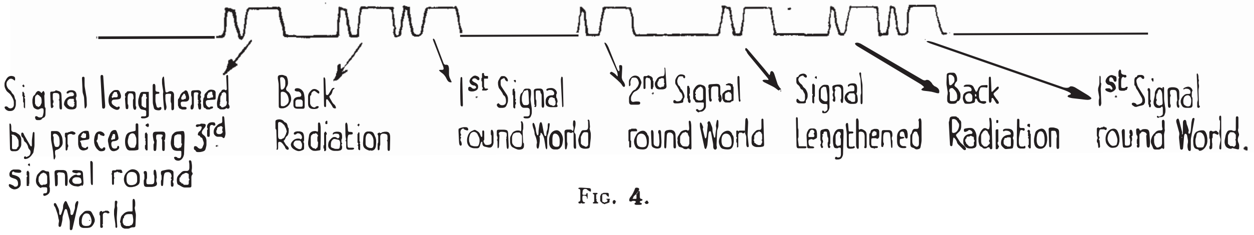

Fig. **4**.

All the above mentioned records were obtained during the period 1700-1800 GMT, *i.e.*, soon after the total path between South Africa and England was in darkness, with the exception of one on November 19th which was obtained between 1900 and 2000 GMT.

Similar observations have been taken at Skegness on signals arriving from the Indian Beam Station. Fig. **2** is a sample of normal reception of slips signalling the letter A at spaced intervals.

This slip is perfectly clear. The receiver coupling was then increased above that required for normal reception and the following slip (Fig. **3**) shows the signalled letter and then a complete duplication of it in the spaced portion due to back radiation from the Indian aerial. This is followed immediately by a third letter, which has been produced by signals encircling the world and back to England.

One sample (Fig. **4**) was obtained which shows not only the above effect but a fourth reception of the letter A after the signal had gone round the world a second time. Further, the dot and dash of the succeeding letter A appear to have been lengthened, suggesting that a third encircling signal of the preceding letter has been received which has come nearly into phase with it.

NOTES & COMMENTS

OWING to the extraordinary demand for last April number, the issue has been completely sold out, in spite of the fact that what was thought to be ample provision had been made. In addition to many outstanding orders which cannot be met, it is understood that many Australian subscribers did not receive their copies, owing to some mishap to the mail by which the journals were despatched. We should like to meet all calls upon us, especially those from the Antipodes, and in order to do so we are prepared to buy in copies, in good condition, of the April issue. Full price will be paid. Will district subscribers who do not desire to retain their April copies please send them to their local agents; those at headquarters should hand the copies to Mr. H. Riddle, Lobby, Alder House.

Not a few of the older members of the engineering staff will regret the death of Mr. H. W. Sidney Rentall, editor of "Electricity," who passed away quietly in his sleep on Saturday morning, 22nd October. For many years he catered for the P.O. student by publishing telegraph and telephone matters in his paper, which he took over in 1894, and the firm also published many books on these and kindred subjects which were exceedingly helpful in the early days. He was a man of the most genial disposition, an enthusiastic Freemason, and known to almost everybody in the electrical industry.

In "Annales des Postes, Télégraphes et Téléphones," for October, 1927 (Vol. 16, No. 10), there appears under the title "Apercu du Probléme des Liaisons en Téléphonie Automatique," an article by Mr. G. F. O'dell, of the Engineer-in-Chief's Office, whose contributions to the literature of automatic telephony are well known to our readers. The article is prefaced by an editorial note, of which the following is a translation:—

"Mr. O'dell, an engineer in the British Post Office service, who is an authority on the question of automatic telephony, read a paper on this subject in London on the 2nd December last at a meeting of the Institution of Electrical Engineers, which has been published in full in the February number of the Institution Journal. The meeting discussed, fully and authoritatively, all the main up-to-date points of interest on the subject of automatic telephony, and we are particularly pleased that Mr. O'dell has himself prepared for our Annales the resumé which follows. We return to him our best thanks. Those of our readers who are not acquainted with the English language will thus be able to appreciate the views of Mr. O'dell."

A summary of the same paper appeared in our July issue. For this paper Mr. O'dell was awarded the Fahie Premium by the Institution.

The November issue of *Les Annales* is a particularly interesting number, having excellent articles on (*a*) Thunder and Lightning in its different forms, by E. Mathias, Director of the observatory of the puy de Dôme, (*b*) a generalisation of diagrams of Kennelly, by J. de Goer, (*c*) Tele-photography, by Georges Kette and Walter Kiel, and (*d*) the present state of the problem of Television by G. Valensi. The first article occupies 43 pages and includes several very good illustrations of lightning in France, England and elsewhere; the third article is a study of new methods in the electrical transmission of pictures translated from an article which appeared in the *Telegraphen und Fernsprech Technik* of February, 1927; the fourth article covers 21 pages with numerous illustrations.

Colonel T. F. Purves and Mr. E. H. Shaughnessy have just returned from the United States, where they had been attending the Radiotelegraph Conference at Washington. The Engineer-in-Chief was the Head of the British delegation, which included also among its members Messrs. F. W. Phillips, J. Louden and A. J. Waldegrave of the Secretary's Office. The Chief and his Assistant took the opportunity of inspecting the latest developments in communication engineering in the States, and their visit will no doubt bear fruit in the home service.

We regret very much having to record the death of Mr. M. Ramsay, late head of the Equipment Section at Headquarters, who retired from the service early in the year. A sketch of his career appeared in our July issue, and in it the writer expressed the hope that free from the cares and worries of office Mr. Ramsay would be enabled to prolong his life for years and that his latter days would be free from anxiety and pain. The hope was not realised, however, and another good man has gone to his rest. He collapsed rather quickly in the end, and passed away at three o'clock on the morning of the 6th December. The esteem in which he was held was evidenced by the large gathering which attended his funeral on the 9th ult. at the Great Northern Cemetery. Many of his colleagues from headquarters were present and they were pleased to see prominent representatives from the several contractors' firms who had been closely associated with him in the telephone business. Some forty wreaths were sent as tokens of remembrance of a very able engineer and of a man whose straightforward qualities of mind and heart endeared him to all who knew him. The sincerest sympathy is offered to Mrs. Ramsay and family.

This autumn has taken another toll from the list of retired P.O. engineers in the person of Mr. C. H. Chapman, who spent all his engineering service at Holloway and Studd Street, and who had been receiving his pension for only about three years. C.H., who was the elder brother of A.E., of Bristol, enjoyed good health after his retirement, but succumbed suddenly to a stroke of paralysis. He is buried in Marylebone Cemetery; the funeral service was attended by many of those colleagues who had gone through the test rooms earlier in their careers and by friends in North London, in addition to members of the family.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Burnley	New Auto.	1650
Cheltenham	,,	1120
Fforestfach	,,	140
Gillingham	,,	570
Hereford	,,	1040
Oxford	,,	1060
Syston	,,	130
Headingley	Auto. Extn.	500
Hurley	,,	30
Bearsden	New Manual	720
Belfast Relief	,,	3610
Hatch End	,,	386
Horley	,,	660
Merstham	,,	340
Lee Green	Manual Extn.	2240
Malvern	,,	200
Norwich	,,	720
Paddington	,,	1060
Sevenoaks	,,	640
Streatham	,,	1480
Walton (Liverpool)	,,	420
Wilmslow	,,	340
Barrow Corporation	P.A.B.X.	40
Carl, F., Ltd.	,,	30
Carlisle Co-op.	,,	30
Cumberland Council	,,	40
Daily News	,,	30
Hall & Co.	,,	100
Meccano Ltd.	,,	50
Newcastle Corporation	,,	130
Ocran Coal Co.	,,	10
Pendleton Co-op.	,,	30
Shell Mex (Aberdeen)	,,	20
,, ,, (Birmingham)	,,	20
,, ,, (Newcastle-on-Tyne)	,,	20
Shropshire etc. Power Co.	,,	40
Synthetic Ammonia	,,	200
Waring & Gillow	,,	170

Orders have been placed for the following new **works** :—

Exchange.	Type.	No. of Lines.
Edgware	New Auto.	1300
Hipperholme	,,	347
Ilford	,,	2850
Leeds Auto. Power Plant	,,	Rearrangements
Primrose Hill	,,	6900
Shepherds Bush	,,	4100
Sowerby Bridge	,,	440
Gosport	Auto. Extn.	270
Halifax	,,	Rearrangements
Oxford	,,	,,
Portsmouth	,,	,,
Southampton	,,	540
Ashford	New Manual	500
Bramhall	,,	1040
Emberbrook	,,	1660
Godalming	,,	780
Haywards Heath	,,	540
Molesey	,,	2280
Norbury Relief	,,	1900
Chiswick	Manual Extn.	2140
Queens Park	,,	1080
South Shields	,,	1360
Waterloo (Liverpool)	,,	960
Wavertree	,,	1040
Weybridge	,,	300
Weymouth	,,	240
Bristol Corporation	P.A.B.X.	50
Bristol Tramways	,,	210
Brysilka	,,	20
Carl & Co., F.	,,	30
Heelas & Sons	,,	30
Huntley & Palmer	,,	170
Jaeger & Co.	,,	10
Kingham & Sons	,,	30
Morris Cars (Smethwick)	,,	80
Phillips, J. & N.	,,	30
Rochdale Corporation	,,	160
Shell Mex (Barton)	,,	20
Wolverhampton Union	,,	30

THE FOURTH CONFERENCE OF THE INTERNATIONAL TELEPHONE COMMITTEE ("C.C.I.").*

THE conference at Como from 5th-13th September, 1927, was the first to be held under the reorganisation whereby the "Permanent Commission" was abolished and the work of the annual conference confined to the approbation, discussion, or rejection of the reports prepared, by the various commissions of reporters, upon the groups of questions detailed for investigations at the last conference.

These reports were considered in sections comprising :—

(1) Questions dealing with the general organisation of the Committee.

(2) Telephone engineering questions upon the transmission efficiency, maintenance, and supervision of lines and installations.

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* *Committee Consultatif International des Communications Téléphoniques à Grande Distance.*

(3) Questions of telephone traffic and exploitation.

(4) The protection of telephone cables from corrosion due to electrolysis and chemical action.

At the opening session Dr. Di Pirro (Italy) was unanimously elected President of the Conference, and Dr. Breisig (Germany) and M. Van Embden (Holland) were elected Vice-Presidents; M. Milon (France) being appointed Hon. Vice-President.

QUESTIONS OF GENERAL ORGANISATION.

The General Secretary, M. Valensi, submitted his report upon the work of the Committee since the last Conference, and reports upon actual expenditure for the year 1926 and the proposed expenditure for the years 1927 and 1928, the latter including the expenditure due to the installation and operation of the European Master Reference System for the calibration of telephone apparatus. The Conference agreed upon certain measures to give effect to economy in the administration of the "C.C.I."

The expenditure incurred by the "C.C.I." is met by the distribution of costs among the Nations represented at the Committee, the scale of contributions corresponding to that adopted by the International Telegraph Union:—

1st Class. Germany, France, Great Britain, Union of Sovietic and Socialistic Republics.
2nd Class. Spain, Poland.
3rd Class. Belgium, Finland, Norway, Holland, Rumania, Jugo-Slavia, Sweden, Czecho-Slovakia.
4th Class. Austria, Denmark, Hungary, Switzerland.
5th Class. Esthonia, Latvia.
6th Class. Luxembourg, Mozambique.

The only European countries not represented on the "C.C.I." are Albania, Bulgaria, Greece and Turkey.

It was decided that the chief reporter of each commission of reporters will be elected by the plenary assembly and that members of these commissions need not necessarily express the views of their respective Administrations, since such official views, in connection with each question submitted for study, are sought by the General Secretary of the "C.C.I." The "C.C.I." is solely an advisory body and Administrations are not bound to accept its recommendations.

A special travelling commission was appointed to deal with inter-bourse traffic procedure and other traffic problems.

TELEPHONE ENGINEERING QUESTIONS.

The Unit of Transmission. The nomenclature for the unit of transmission was finally settled by adopting the title "Néper" for the natural logarithmic unit and "Bel" for the common logarithmic unit. The symbols for these units have not been selected and it will be necessary to employ the names in full for the present. In international service and in documents of the "C.C.I." transmission and cross-talk values will be expressed in both units.

By the general definition proposed by the "C.C.I." the unit of transmission serves to express the ratios of apparent or real powers, voltages or currents in transmission systems. In practice the number of units for a given case is determined by a logarithmic expression as follows:—

(1) If the two powers P_1 and P_2 are concerned, the number of Népers $= \frac{1}{2} \log_{nat} \frac{P_1}{P_2}$, and the number of Bels $= \log_{10} \frac{P_1}{P_2}$. The "Decibel," which is 1/10th of the Bel and is the renamed "T.U.," will be more conveniently employed in practice. Hence the number of Decibels $= 10 \log_{10} \frac{P_1}{P_2}$.

(2) If two voltages $V1$ and $V2$ or two currents I_1 or I_2 are concerned, the number of units become $\log_{nat} \frac{V_1}{V_2}$ or $\log_{nat} \frac{I_1}{I_2}$ in Népers, $2 \log_{10} \frac{V_1}{V_2}$ or $2 \log_{10} \frac{I_1}{I_2}$ in Bels and $20 \log_{10} \frac{V_1}{V_2}$ or $20 \log_{10} \frac{I_1}{I_2}$ in Decibels. The fact that the new name for the basic unit was chosen as that of the inventor of the telephone is not apparent on account of the spelling adopted.

Permissible limits of transmission loss due to apparatus in circuit. The Conference dealt in detail with the report of the 3rd Commission of Reporters and, after resubmission of certain questions, made the following recommendations:—

(i) It is desirable that the transmission equivalent between two subscribers on an international circuit should not exceed 3.3 népers or 28.6 decibels.

(ii) The transmission equivalent of an international circuit, including the line terminals, should not exceed 1.3 népers or 11.0 decibels.

(iii) In order to ensure that any subscriber may be connected to any subscriber in another country, it is necessary that losses resulting from the whole of the connections joining the subscriber to the terminals of the input transformer of the international circuit should not exceed 1 néper or 8.7 decibels.

This figure shall include the whole of the losses in the connections used to join the subscriber to the terminals of the input transformer of the international circuit, the secondary trunk line, the intermediate exchanges and the accessory apparatus in series or shunt, and the subscribers' lines, but shall not include the losses due to the reduction in the current supplying the microphone from the central battery of the exchange.

(iv) When the master reference system for the calibration of telephone apparatus and working standards is available it will be necessary to define the transmission equivalent of the complete connection between the subscriber and the terminals of the output transformer of the international circuit. The permissible limit of maximum transmission loss at a junction point on an international circuit, due to signalling and monitoring apparatus (electro-magnets, resistances, condensers, keys, including the internal wiring of the trunk exchange) should not exceed 0.20 népers or 1.7 decibels within a frequency range of 300 to 2,500 periods per second, the loss due to signalling apparatus being reckoned at approximately 0.05 népers or 0.43 decibels, those due to monitoring apparatus being taken as 0.09 népers or 0.78 decibels, the internal wiring of the trunk exchange being put at 0.06 népers or 0.52 decibels.

General Conditions to be satisfied by Overhead Lines used for International Circuits. While it is not possible to define immutably and generally the geometric and mechanical constants of the configuration of overhead lines, the choice of these values being a function not only of electrical factors but also of economic factors, which vary according to the season of the year and according to the country where they are constructed, it is recommended that for the construction of international long distance telephone lines conductors of a gauge equal to or more than 3 mm. and offering a mechanical resistance sufficient to reduce causes of rupture to a minimum should be used. It is also recommended that the stability of a pole line should be such that it is able to resist as far as possible the maximum strain due to storms, hail and snow.

(i) So far as the electrical qualities of aerial lines are concerned the conductors employed should consist of copper or copper alloy in which the conductivity does not vary by more than 10% from that of copper of high conductivity or a metal or alloy affording the same advantages and satisfying the following conditions:—

(ii) In a repeater section or between a repeater station and an adjacent terminal office, the metal, gauge of conductors and the distance between the conductors on a long distance telephone circuit should always remain the same in order to ensure satisfactory uniformity. In order to ensure this uniformity, the variation of the impedance-frequency characteristics of the mean curve should not exceed 5%.

(iii) All the joints in an overhead line should be made in such a manner that they do not introduce variable resistance.

(iv) In any section of overhead line between repeater stations or between a repeater station and an adjacent terminal office, the difference of resistance between two conductors of any pair, measured by direct current, should not exceed 2 ohms.

(v) In order to avoid cross-talk interference and the disturbing effects of high power installations and telegraph circuits, the wires of long distance international telephone circuits should be crossed or rotated in such a manner that the section over which anti-induction is complete between any two circuits of the network shall be less than $\frac{1}{4}$ of the wave-lengths of the telephone circuits; in the case of high frequency carrier current telephony, and also where disturbing effects, due to high power installations, occur, or in the vicinity of telegraph circuits, it may be desirable to reduce the crossing or rotation periods.

(vi) So far as concerns danger or interference due to high power installations, telephone circuits should satisfy the conditions indicated in the "Directives" relating to protection already promulgated by the C.C.I.*

(vii) The insulation of each of the wires with respect to earth should not fall below the value of 1 megohm per kilometre, which experience in various countries has shown to be a practicable value under normal conditions of the atmosphere, from the point of view of humidity; the maintenance of this insulation is possible by using double-shed insulators, suitably constructed. This value may be reduced in districts where the climate is exceptionally humid.

(viii) The transmission equivalent between two repeater stations or between a repeater station and the adjacent terminal office should not exceed 1.6 népers or 13.9 decibels.

(ix) Circuits should be provided with testin points in accordance with the C.C.I.'s recommendation contained in white book, page 100.†

The recommendations relating to the testing points on international circuits are:—

(*a*) The number of leading-in points should be reduced to a minimum compatible with local requirements.

(*b*) The testing points enabling precision tests to be effected should be installed approximately 200 km. apart.

(*c*) Tests for conductivity and insulation of the conductors shall be made at least once a month by the terminal exchanges or the repeater stations nearest to the frontier and the results of these tests shall be exchanged between the services concerned.

Cable Sections of Overhead Lines. General conditions were settled in respect to the construction and loading of aerial cables to limit transmission losses and impedance irregularities.

Simultaneous use in the same Cable of Telephone and Telegraph Circuits. The Conference provisionally accepted the following conditions which should satisfy the present technique regarding simultaneous, or co-existent, telegraph and telephone installations in order that the transmission quality of telephone circuits may not be prejudiced.

1. The E.M.F. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through the resistance must not exceed 50 m.A.

3. The increase in attenuation of the telephone line due to infra-acoustic telegraph installations must not exceed 0.06 Népers or 0.5 Decibels for a line section between two succes-

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* *Space will not permit the publication of these instructions at present.*

† *The official publication in French of the Comité Consultatif International.*

sive repeaters and over the frequency range of 300 p.p.s. to the maximum telephone frequency transmitted.

4. The variation of the line impedance of 4-wire circuits must not exceed 10 per cent. in that frequency range; as regards 2-wire cicuits the variation must not exceed the values prescribed by the " C.C.I. " for the exact simulation of the impedance of the line by balancing networks.

5. Interference noise produced in telephone circuits by telegraph apparatus must not exceed, for a transmission level of −1.0 Népers or −8.7 Decibels on a circuit of 800 ohms impedance, a value which corresponds to an interference voltage of 0.1 *mV*.

6. The increase in cross-talk produced by infra-acoustic telegraph installations shall be determined as follows:—

The cable quads are replaced by artificial lines free from cross-talk and reproducing, within the closest possible limits, the impedance of the circuits. Under these conditions the attenuation corresponding to the cross-talk measured from the telephone office side must not be inferior to the following values:—

a. For 4-wire circuits: 7.5 Népers or 65 Decibels for the cross-talk between any two speech circuits in the same quad.

b. For 2-wire circuits: 8.5 Népers or 74 Decibels for the cross-talk between any two speech circuits in the same quad.

c. For 4-wire and 2-wire circuits: 10 Népers or 87 Decibels for cross-talk between two speech circuits in different quads.

7. For international communications the total length of circuit sections employed simultaneously for telephony and infra-acoustic telegraphy must not exceed 450 km.

8. The infra-acoustic telegraph systems must not introduce an unbalance to earth in excess of the value prescribed by the " C.C.I."

In the case of co-existent telephony and telegraphy over separate conductors conditions 1, 2 and 5 above must be fulfilled for loaded conductors but condition 1 only for non-loaded conductors.

In the case of voice-frequency telegraph systems, the sum of the effective voltages corresponding to the frequencies used simultaneously on the same circuit should be less than 2 volts and the sum of the corresponding effective currents should be less than 2 mA. When it is required to use currents or voltages exceeding these values it is preferable to choose circuits allotted to telegraph purposes in the outer layers of the cables and to balance them in separate groups. The final decision in these matters will be taken on the completion of tests at present being conducted by the various Administrations.

The choice of frequencies for carrier current telegraphy will probably be decided exclusively by the " C.C.I. Telegraphs."*

THE STANDARD REFERENCE SYSTEM.

On the motion of the British delegation, it was decided to convey the unanimous and cordial thanks of the " C.C.I.." to the American Telephone and Telegraph Company for having generously made a free gift of the costly European Master Reference equipment, and for their proposal to send to Paris at the beginning of the year an engineer to supervise its installation, and at the same time to convey the thanks of the Committee to the French Government, as represented by the Post Office Administration and the Conservatoire des Arts et des Métiers, for having placed at disposal, without charge, excellent accommodation in the centre of Paris for the European Master Reference System.

INTERNATIONAL CIRCUIT MAINTENANCE.

Amongst the miscellaneous matters dealt with by the engineering section was the recommendation to apply experimentally a programme of maintenance testing designed to ensure maximum efficiency in the maintenance of long distance international circuits. This programme was elaborated by the British, Dutch and German Administrations some time ago, and met with the entire approval of the Conference.

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* *Internation Consultative Telegraph Committee.*

LONDON DISTRICT NOTES.

TELEGRAPHS.

Central Telegraph Office.—Creed Start-Stop apparatus has been fitted on the following circuits:—

Carlisle.
Colchester.
Croydon.
Norwich (two sets).
Leather Cloth Company's P.W. (London).

A school for training skilled workmen in the maintenance of machine telegraphs has been fitted up within the C.T.O. The equipment includes:—

6 Teletypes, No. 1-A.
6 ,, No. 2-A.
6 Transmitters, Creed No. 1.
6 Receivers, Creed No. 4,
and Auxiliary apparatus,

and facilities are given for loop, or universal, power working.

Central Radio Office.—Sixteen perforators of the new Creed type have now been installed in the Central Radio Office.

A weight-driven, but motor-wound, Wheatstone transmitter has been fitted to one of the Beam stations in the Central Radio Office and the four services—Australia, Canada, India and South Africa—have been provided with Wheatstone checking sets.

Typewriters have now become engineering items and seventy-two of the new design have already been brought into use for the Beam Services.

Pneumatic Tubes.—The last of the tubes to the War Office Pneumatic Tube Centre * namely, that to Charing Cross Railway Station, has been completed and is working. The Station portion of the Tube is of brass and is run from the platform telegraph-office by way of the roof trusses and the wall adjacent to the railway lines, to the lead street tube beneath the railway bridge. The route is very tortuous, but in spite of this, the transit time is only thirty seconds over a distance of 552 yards.

TELEPHONES.

The changes in the number of Exchange Lines, Extensions and stations during the quarter and the totals on 30th September, 1927, were as follows:—

	Increase.	Total.
Exchange Lines ...	4,823	319,074
Extensions ...	3,907	271,375
Stations	8,324	538,184

EXCHANGE WORKS.

Toll Exchange A.—This exchange, situated in the G.P.O. (South), Carter Lane, E.C., was opened on December 3rd and marks an important stage in the provision of additional facilities for London Toll traffic. Its capacity is 5,250 lines, and the equipment consists of 158 control positions and 29 through positions. The main object of the exchange is to handle outgoing traffic, leaving the original Toll Exchange (in Norwich Street, Fetter Lane) now known as Toll B, to deal with the remaining traffic.

Holborn Automatic Exchange.—The first automatic exchange to be opened subsequent to Tandem (Junction Exchange) was cut in on November 12th, shortly before midnight. The change-over was entirely successful and 4,792 subscribers were transferred from old Holborn Manual Exchange to the new system. During the few days immediately following the opening there was considerable congestion due mainly to the abnormal amount of traffic and to dialling errors and other mistakes. The successful way in which the traffic was handled by the switching apparatus augurs well for the success of the change of London's telephone system from manual to automatic working.

Other Automatic Exchanges.—Steady progress has been made with the installation of automatic exchanges at:—

Bishopsgate, Sloane, Western, Bermondsey, Monument, Maida Vale, Temple Bar, Langham, Edgware.

The Bishopsgate and Sloane Exchanges will be opened early in the New Year and the remainder, it is hoped, at various dates during 1928-29.

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* *See Vol. XIX., Part 1, page 4, Apl., 1926.*

C.B. Exchanges.—C.B. Exchanges are on the point of completion at:—

Hatch End (C.B. No. 10, 400 lines).
Merstham (C.B. No. 10, 340 lines).

A C.B. Exchange at Barnes to be known as "Prospect" is also nearing completion and will afford much needed relief to the Richmond Exchange.

A temporary C.B. Exchange, to be known as "Ambassador," is being installed in the Paddington Exchange building and will afford relief to the Mayfair Exchange.

Extensions of C.B. exchanges have been completed at:—

Finchley	for	1740	lines.
Lee Green	,,	2240	,,
Mountview	,,	980	,,
Purley	,,	600	,,
Streatham	,,	2480	,,

Extensions of other C.B. exchanges to be completed early in 1928 are in hand at:—

Chiswick	for	2140	lines.
Riverside	,,	1380	,,
Wanstead	,,	1540	,,

EXTERNAL PLANT.

The changes in mileage during the three months ended 30th September, 1927, and the totals on that date were as follows:—

Single Wire Mileage.

Telegraphs.—A nett decrease in open wire of 10 miles and a nett increase in underground of 111 miles.

Telephones (Exchange).—A nett decrease of open wire (including aerial cable) of 137 miles, and a nett increase in underground of 59,511 miles.

Telephones (Trunk).—A nett decrease in open wire of 23 miles, and a nett increase in underground of 550 miles.

Pole Line.—A nett increase of 52 miles, the total to date being 5,779 miles.

Pipe Line.—A nett increase of 364 miles, the total to date being 9,250 miles.

The total single wire mileages at the end of the period under review were:

Telegraphs	24,789
Telephones (Exchanges) ...	2,121,818
Telephones (Trunk) ...	67,185
Spares	135,017

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

Programmes, 1927-28.

LONDON CENTRE.

1927.	
11 Oct.	F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. "Satellite Working in Automatic Areas."
8 Nov.	T. Fewster and F. Johnston, A.C.I.S. (*Northern Centre*). "Accounting as a function of Management."
13 Dec.	A. H. Jacquest, A.M.I.E.E., and L. H. Harris, M.Sc. (Lond.), A.C.G.I. "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits."
1928.	
10 Jan.	P. G. Hay, F.S.I., M.I.E.E., and J. N. Hill. "The Evolution of an Exchange Area."
7 Feb.	C. W. Brown, A.M.I.E.E., and R. J. Hines, B.Sc. "The problem of the P.B.X. converted to a public Automatic Exchange."
6 Mar.	A. B. Hart, M.I.E.E. (*Title of paper not yet available*).
8 May.	Capt. B. S. Cohen, M.I.E.E. (*Title of paper not yet available*).

Informal Meetings.

1927.	
25 Oct.	Capt. J. C. Hines, M.I.E.E. "The Telephone Engineer and his job."
22 Nov.	Major H. Brown, M.I.E.E. "Some things we all think we know."
1928.	
24 Jan.	G. T. Evans. "Some small current Rectifiers and their Characteristics."
21 Feb.	W. Day, M.I.E.E. "The Philosophy of Engineering."
20 Mar.	H. E. Morrish. "My idea of the functions of a Technical Section."
24 Apl.	E. P. Neate. "Fault Location in Local Lines."

NORTH EASTERN CENTRE.

1927.	
11 Oct.	T. P. Barlow. "Railway Signalling—Automatic."
8 Nov.	W. H. Thornburn. "New Promotion Scheme."
13 Dec.	E. H. Farrand, M.I.E.E. "Telephones in Spain."
1928.	
17 Jan.	H. Trickett. "External Work in connection with the Halifax Exchange Transfer."
27 Feb.	F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*). "Satellite Working in Automatic Areas."
Date not yet fixed.	T. B. Johnson, M.I.E.E. "P.O. Engineer, Past, Present and Future."

NORTH WESTERN CENTRE.

1927.
10 Oct. T. Kenyon.
"Motor Transport."
7 Nov. W. G. Morris and A. J. Ross.
"Office Filing Economics."
5 Dec. A. S. Carr, B.E. (Cantab.), A.M.I.E.E.
"Automatic Telephony in Southport Multi-Exchange Area."
1928.
16 Jan. A. L. Barclay. (*Telephone Traffic Dept.*).
"Traffic Arrangements as they apply to Automatic Exchange Transfers."
13 Feb. T. Woodhouse, A.M.I.E.E.
"Rebalancing a Cable."
12 Mar. W. S. Procter.
"Some Experiences in Loading and Final Tests of Main Trunk Cables."

NORTHERN CENTRE.

1927.
14 July. Visit to Cowgate Repeater Station.
19 Oct. F. G. C. Baldwin, M.I.E.E.
"Telephone Switching."
16 Nov. F. W. Longmore.
"Trunking in Automatic Telephone Systems."
21 Dec. T. Fewster and F. Johnston, A.C.I.S.
"Accounting as a function of Management."
1928.
18 Jan. G. F. Bellwood, A.M.I.E.E.
"Through Signalling on Trunk and Junction Circuits."
15 Feb. W. Weightman.
"Laying of Holy Island Cable."
21 Mar. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."

SOUTH LANCS. CENTRE.

1927.
17 Oct. W. J. Medlyn, M.I.E.E.E.
"Progress and Development in the P.O.E.D."
14 Nov. C. W. Brown, A.M.I.E.E. (*E.-in-C.O.*).
"The Director—its application and the Functions Performed."
12 Dec. T. Cornfoot, M.I.E.E.
"The Administration of an Engineer's Section."
1928.
24 Jan. H. C. Gunton, M.B.E., M.I.E.E. (*E.-in-C.O.*).
"Recent Applications of Power in the Post Office."
(*Joint meeting with I.E.E.*).
6 Feb. T. Fewster and F. Johnston, A.C.I.S. (*Northern Centre*).
"Accounting as a function of Management."
5 Mar. Capt. W. Cowburn, A.M.I.E.E.
"Telephone Engineering Economics."
2 Apl. F. E. Bentley, A.M.I.E.E. and L. H. Crane, A.M.I.E.E.
"U.G. Cable Maintenance. Notes on results of 3 years special testing."

NORTH WALES CENTRE.

1927.
12 Oct. R. T. Robinson, A.M.I.E.E. (*E.-in-C.O.*).
"Motor Transport."
9 Nov. J. Ree. (*Mullard Wireless Services Co.*).
"Thermionic Valves and Distortionless Amplification."
8 Dec. Capt. J. Coxon, M.I.E.E.
"Exchange Power Plant."
(Meeting at Birmingham and visist to Exchange).
1928.
11 Jan. C. G. A. McDonald. (*Leafield Radio Station*).
"The running of a large Wireless Station."
1 Feb. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
22 Feb. R. Sheppard.
"Exchange Construction."
14 Mar. E. A. Pearson, A.M.I.E.E.
"Waste."

SOUTH WALES CENTRE.

1927.
10 Oct. A. S. Renshaw. (*E.-in-C.O.*).
"Some General Considerations relating to the Clerical Organisation of the Engineering Department."
14 Nov. T. R. Tombs.
"Gloucester Automatic Transfer, including Development."
12 Dec. Col. A. G. Lee, O.B.E., M.C., B.Sc., M.I.E.E. (*E.-in-C.O.*).
"Wireless."
1928.
9 Jan. R. G. Allcock.
"Estimates."
S. E. Hailes.
"H. Relay."
H. R. Mullis and T. L. Peacock.
"Motor Transport."
13 Feb. W. Cruickshank, M.I.E.E. (*E.-in-C.O.*).
"Voice Frequency Telegraphs."
12 Mar. H. C. A. Linck.
"Multi-Office Relay Automatics."

SOUTH WESTERN CENTRE.

1927.
20 Sept. Chairman's Address.
17 Oct. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
13 Dec. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Auto. Multi-Office Transfer."
1928.
17 Jan. W. Vickery.
"Trench Restoration."
14 Feb. C. W. Brown, A.M.I.E.E. (*E.-in-C.O.*).
"The Problem of the P.B.X. Subscriber Connected to an Automatic Exchange."
20 Mar. Visit to Exeter Automatic Exchange.

NORTH MIDLAND CENTRE.

1927.
10 Oct. J. Coote.
"Junction Working to Automatic Exchanges."
7 Nov. C. H. Thatcher.
"Auxiliary Power Plant Services, Sheffield Automatic Exchange."
5 Dec. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
1928.
16 Jan. B. Glen.
"Tests applied to Underground Main Cables."
6 Feb. R. H. Hunt.
"Traffic Meter Readings."
5 Mar. J. R. Milnes.
"Power Interference."
26 ,, C. A. Carpenter.
"Transmission on Low Power."
Visit to Nottingham Super Power Station.

SOUTH MIDLAND CENTRE.

1927.
24 Oct. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
30 Nov. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Automatic Multi-Office Transfer."
21 Dec. V. Smith.
"Electrolytic Action."
1928.
25 Jan. S. D. Pendry.
"Repeater Station Test Desks."
29 Feb. C. E. Moffatt, A.C.G.I.
"Line Plant Formulæ and Calculations."
28 Mar. W. H. Arnold.
"Thrust-borers and Thrust Boring."

EASTERN CENTRE.

1927.
26 Oct. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
29 Nov. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Automatic Multi-Office Transfer."
1928.
17 Jan. R. T. Robinson, A.M.I.E.E. (*E.-in-C.O.*).
"Motor Transport in the Engineering Department).
20 Feb. F. Guest.
"Youths, Their Recruitment, Training and Technical Education in the P.O.E.D."
20 Mar. L. G. Semple, B.Sc.
Subject to be arranged.

SCOTLAND EAST CENTRE.

1927.
24 Nov. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
20 Dec. R. T. Robinson, A.M.I.E.E. (*E.-in-C.O.*).
"Motor Transport."
1928.
17 Jan. Short papers and informal discussions.
21 Feb. E. H. Shaughinessy, O.B.E., M.I.E.E. (*E.-in-C.O.*).
"Rugby Radio Station."
(*Joint meeting with I.E.E.*).
20 Mar. J. McIntosh.
"Forms and Methods in preparing Estimates."
17 Apl. J. Innes, B.Sc.
"Service Observation Equipment in Auto. Exchanges."

SCOTLAND WEST CENTRE.

1927.
4 Oct. R. T. Robinson, A.M.I.E.E. (*E.-in-C.O.*).
"Motor Transport."
7 Nov. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Auto Multi-Office Transfer."
5 Dec. A. Arnold.
"Glasgow Repeater Station" (*or alternative*).
1928.
Feb. *To be arranged.*
Mar. *To be arranged.*

NORTH IRELAND CENTRE.

1927.
8 Nov. Major G. H. Comport, M.C., M.I.E.E., R.E.
"Motor Transport."'
6 Dec. Capt. F. G. C. Baldwin, M.I.E.E. (*Northern Centre*).
"Scientific Organisation and the P.O. Engineering Department."
1928.
10 Jan. G. Bailey, A.M.I.E.E. (*North Eastern Centre*).
"Preparation of Underground Development Schemes."
14 Feb. N. Ashbridge, B.Sc., A.M.I.C.E. (*B.B.C., London*).
"Broadcasting."
6 Mar. Visit of Inspection of Harland & Wolff's Belfast Shipbuilding Yards.
23 Mar. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
10 Apl. J. Cleaver, A.M.I.E.E. (*S. Lancs. Centre*).
"Problems in large Underground Works."

LOCAL CENTRE NOTES.

NORTH WESTERN CENTRE.

Chairman, J. M. Shackleton; Vice-Chairman, J. Sinclair Terras; Committee, S. Upton, W. Beattie, R. A. Jones, R. A. G. Chambers, E. Hopper, and H. S. Turner; Hon. Librarian, H. Howarth; Local Secretary, D. Barratt.

The opening meeting of the 1927-28 Session was held in the Lecture Hall of the Preston Scientific Society, Fishergate, Preston, on the 10th October, 1927, when a paper entitled "Motor Transport" was read by Mr. T. Kenyon, of the South Lancashire Centre. Mr. Shackleton presided.

Mr. Kenyon opened his paper with a review of the evolution of the motor transport services in the Engineering Department and proceeded to deal with the subject under the following headings:—Constitution of Department's Fleet, Organisation and Uses, Running Costs, Statistics, Hired Transport, Staff Co-operation, Observations and Suggestions. The lecture was illustrated by an excellent set of lantern slides, and a useful discussion followed.

On the 7th November, 1927, a paper, entitled "Office Filing Economics," was read at Preston by Messrs. W. G. Morris and A. J. Ross.

The objects in view were the reduction of filing work in offices in which filing had become more laborious than circumstances warrant and the introduction of a simplified system in offices in which filing had lapsed on supposed economic grounds. The existing filing arrangements in the various groups of the District Headquarters Office were reviewed and this was followed by proposals for filing in the Sectional Engineers' Offices and at outlying Inspectors' stations.

Diagrams illustrating the arrangement of filed matter in the office presses and the most suitable positions for card cabinets were projected by Electric Arc Lantern. There was an interesting discussion, when many points were raised and replied to.

D. Barratt, *Secretary*.

SOUTH LANCASHIRE CENTRE.

The Session opened on October 17th with an Address by the Chairman, Mr. W. J. Medlyn, in which, under the title of " Progress and Development in the Post Office Engineering Department," he gave an interesting review of the various activities of the Engineering Department during the past year and an outline of the latest Telephone and Telegraph Engineering developments.

The address was followed by a cinematograph film illustrating the use of the " Simplex Jack " on pole recoveries. This was succeeded by a film entitled, " Beyond the range of Vision," showing the wide activities of the American Bell Telephone interests. A Simplex Jack was supplied for demonstration purposes by Mr. W. Tuke Robson, M.B.E., A.M.I.E.E., of the Equipment and Engineering Company. The film illustrating the American Telephone practice was loaned by the Engineer to the Bradford Corporation Electricity Department, through the good offices of Mr. J. Shea.

The thanks of the members was suitably expressed to Messrs. Robson and Shea, both of whom were present, for their interesting and instructive additions to the proceedings.

NORTHERN CENTRE.

The opening meeting of the Session was held on the 19th October, when Mr. F. G. C. Baldwin, M.I.E.E., delivered a lecture, entitled " The Early Development of Telephone Switching," before a well attended gathering.

The lecturer took his audience through the various stages of switching from the earliest days of the first telephone exchange to modern methods of accomplishing intercommunication and the numerous slides which he introduced rendered the address not only interesting and instructive, but easy to follow.

The Committee for the Session has been elected as follows:—

Chairman, J. R. M. Elliott, M.I.E.E., ; Vice-Chairman, F. G. C. Baldwin, M.I.E.E.; Committee, G. A. Peck, M.I.E.E., Jas. A. Motyer, C. P. Kay, W. Weightman, H. J. Millett, A. H. Wade; Local Librarian, T. E. Preston; Local Secretary, A. C. Smith, A.C.I.S.

NORTH WALES CENTRE.

[From the *Shrewsbury Chronicle,* 11-11-27.]

PRESENTATIONS TO MR. T. PLUMMER.

On Wednesday two presentations were made to Mr. Thomas Plummer, of Shrewsbury, who retired last July from the post of Superintending Engineer of the North Wales District of the General Post Office, after a total service of 42 years.

The occasion was a tea held in Morris's New Ballroom, Pride Hill, Shrewsbury, attended by about 140 members of the engineering staff of the district. Mr. H. A. Jackson, Assistant Superintending Engineer, was in the chair.

Mr. Jackson said they were all sorry to lose Mr. Plummer, because he had endeared himself to them to an exceptional degree. His chief mottoes throughout his official period must have been " Be just and fear not " and " Honesty is the best policy." They admired his devotion to the department he so faithfully served, the straightforwardness and fairness of his decisions, and the kindly interest he took in the welfare of the staff.

They deplored his late breakdown in health, but noted with pleasure that he was now on the road to recovery, and trusted that he would be spared for many years to enjoy his retirement.

Mr. B. J. Gill, head of the clerical staff in the North Wales District, said that he had been associated with Mr. Plummer for over nine years. He had had opportunities of judging him both as an official and as a man, and had the highest admiration for him in both capacities. The whole of the clerical staff would remember him for his kindness, his great industry, his devotion to duty, and his desire to be just to everyone.

Mr. Jackson then presented Mr Plummer with a solid silver breakfast service, including a tray, which bore the inscription, " Presented to Thomas Plummer, Esq., M.I.E.E., Superintending Engineer, by his staff in the North Wales District, as a mark of esteem on his completion of 42 years' service in the Engineering Department of the General Post Office." The presentation had been subscribed to by members of the staff " down to the very lowest."

Mr. W. J. Medlyn, Superintending Engineer for the South Lancashire District, presented Mr. Plummer with an inscribed silver rose bowl and a silver-mounted tea set from the superintending engineers, staff engineers, and members of the headquarters staff of the G.P.O. He said that it gave him particular pleasure to make the presentation, because he had known Mr. Plummer personally for nearly 40 years, both at headquarters and as a near neighbour at Liverpool and Shrewsbury.

Mr. Plummer, who was received with loud applause, returned thanks in a witty speech.

NORTHERN IRELAND CENTRE, BELFAST.

Mr. H. Deeny, Inspector, an Associate Member of the Institution, retired from the service in November, having reached the age of 62.

His last day of duty was the occasion of a gathering of the staff at headquarters, presided over by the Superintending Engineer, Major G H. Comport, M.C., M.I.E.E., R.E., to say good-bye to him. Mr. G. Laslett, Executive Engineer; Mr. J. Davidson and Mr. H. H. Broomhead, Assistant Engineers; Mr. W. S. French, Inspector, and Mr. J. T. Sims, Chief Clerk, having spoken eulogistically of Mr. Deeny, Major Comport, in felicitous terms, conveyed to him the good wishes of his colleagues and congratulated him very heartily on the esteem with which he was held by all grades in the Service, as evidenced by the large attendance.

In handing to Mr. Deeny a wallet of notes as a tangible expression of the good wishes of the District Staff, Major Comport referred to Mr. Deeny's useful service and clean record, expressing the wish of all for a continuance of the excellent health and vigour which characterised Mr. Deeny, and which he would take with him into his well-earned leisure.

With the Staff's presentation Major Comport also handed to Mr. Deeny the Departmental gratuity.

Mr. Deeny suitably responded.

SOUTH WESTERN DISTRICT.

Presentation to Mr. E. J. Eldridge.

There was a large gathering of the staff of the Post Office, South Western District, Engineering Department, at a garden party held on September 20th, 1927, at No. 8, Woodland Road, Tyndall's Park. The event was arranged in connection with the retirement of Mr. E. J. Eldridge, Superintending Engineer of the South Western District, and among those present were the Assistant Engineer-in-Chief, Mr. A. L. de Lattre, Mr H. Wilson, Superintending Engineer, Cardiff, Mr. C. G. Roach, Assistant Superintending Engineer, Cardiff, and also Mr. W. Pugh, Postmaster-Surveyor, Bristol, and Mr. W. Millar, District Manager, Bristol.

Tea was served indoors and then the company adjourned to a marquee erected in the garden, where the presentation, presided over by Mr. A. E. Chapman, Assistant Superintending Engineer, took place.

Messages of farewell and good wishes were delivered by various representatives of the staff and the presentation, which consisted of a Solid Silver Tea and Coffee Service and a set of Golf Clubs, was made by Mr. A. L. de Lattre, the Assistant Engineer-in-Chief.

An evidence of the general esteem in which Mr. Eldridge was held by his colleagues and staff of the Engineering Department of the Post Office, subscriptions were received from the staffs of the District, the Engineer-in-Chief's office and from the Superintending Engineers of the country.

Music was provided by Mr. Gould's Orchestra and vocal items were contributed by several members of the staff, and a very pleasant evening was wound up with community singing and a spirited rendering of "Auld Lang Syne."

SCOTLAND WEST CENTRE.

The first meeting of the current Session was held in the Societies' Room, Technical College, Glasgow, on 4th October. The lecturer for the day was Mr. R. T. Robinson, A.M.I.E.E., Engineer-in-Chief's Office, who delivered a lecture on "Motor Transport." The subject proved to be one of considerable interest and there was a good attendance and discussion.

For our November meeting the lecturer was Mr. J. Innes, B.Sc., of the Scotland East District, who took for his subject "Edinburgh Auto. Multi-Office Transfer."

There was a large attendance and on conclusion of the lecture several questions were raised, to which the lecturer suitably replied. It is understood the paper is being printed for circulation.

A combination of circumstances prevented Mr. Arnold's fulfilment of the programme fixture for 5th December, but the item may be regarded as postponed, not abandoned. We were fortunate, however, in getting Mr. F. G. C. Baldwin, M.I.E.E., of the Northern District, to fill the gap with his lecture on "The Early Development of Telephone Switching." The lecture drew a large attendance of members and a number of visitors from the Commercial side. About fifty slides illustrative of the evolution of telephone switching were shown on the screen, and in some cases these had a personal as well as a technical interest. The lecture was very interesting throughout and the subsequent discussion was contributed to by visitors as well as members.

BOOK REVIEWS.

"Theory of Thermionic Vacuum Tube Circuits," By L. J. Peters. McGraw Hill Publishing Company. Price 15/-.

The scope of this book is even more limited than the title suggests as it deals almost entirely with the usual triode and associated circuits. This will be clear when it is stated that the book does not deal with diode rectifiers and the "screened grid" valve is dismissed in a paragraph.

The book can be commended as a reasoned mathematical statement of the action of the three-electrode valve in its various uses for radio transmission and reception, but it is only suitable for the electrical engineering student who has already covered the usual mathematical groundwork associated with a degree course in electrical engineering.

Prof. Peters deals with the subject throughout his book mainly from the view point that a triode is a means of resistance neutralisation and, as he states in the preface, "This idea is then used as a unifying thread. . . . . " In consequence, it is a book for the student to read as a whole in order to adapt himself to this particular and useful line of argument.

The reading of an American book usually brings with it the interesting discovery of terms which appear novel on this side of the Atlantic. On the ground that we have enough mis-named quantities already, Prof. Peters refuses to use the expression "mutual conductance" with reference to a valve in his book. Following Prof. E. Bennett, he refers to this constant as the "controlled plate conductance" with the symbol G_{ep}, but the reviewer fears that the expression "mutual conductance" has become so universal that there is little hope of its eradication. However, the term "mutual elastance," used by Prof. Peters for the mutual reactance between two circuits with capacitative coupling, would appear to need a good deal of justification.

The book is clearly written and the mathematical portions are set up in type which is easy to follow; the few misprints noticed are fairly obvious and will cause no difficulty. There are a few useful exercises in circuit calculation throughout the work with which the student can check his progress. The student who reads this book will generally wish to pursue his studies in particular directions elsewhere, and for this reason the book would have been improved by references to other sources of information. The absence of such references is always a handicap to the reader, but the vague reference to a paper, without any indication of title or source, as occurs on page 120, is irritating.

The engineer-graduate who, as a part of his training as a radio engineer, wishes to apply and exercise his electrical theory by a consideration of the circuits associated with triodes should read this book.

R.V.H.

"Principles of Radio Communication." By John H. Morecroft (assisted by A. Pinto and W. A. Curry). Chapman & Hall. Price 37/6. (*Second Edition*).

It is a stupendous task to write a comprehensive treatise on radio engineering; that Prof. Morecroft and his colleagues have made a great attempt is witnessed by the fact that the second edition of this book has 1001 pages and 831 figures. The book has been thoroughly revised; several chapters have been considerably lengthened by the addition of up-to-date information and in consequence it has been necessary to omit several chapters of the first edition.

It must be a great problem to the writers of such a book to know the stage at which such a general treatise should start in its description of elementary science and where it should stop in its elaboration of the details of a particular phase of radio engineering. It used to be the practice for many engineering books to commence with a mathematical introduction, but fortunately it has been realised that the engineer cannot afford to study his mathematics on the basis of a few introductory chapters of a book on engineering. The reviewer is looking forward to the time when writers of books on radio engineering will refrain from using their first chapters to explain to their readers the elementary facts of magnetism and electricity, such as the nature of an electric current, the capacity of a condenser, etc., etc. If Prof. Morecroft had omitted some of the elementary portions of the work and some of the simple figures (such as those showing the use of a fence as a receiving antenna, and of a tree, with nail, as a possible means of support) it would have probably been unnecessary to omit any chapter on "radio-measurements"—which Prof. Morecroft hints may be issued as a separate volume. In view of the fact that the great advances made by radio engineering in recent years have been due largely to the development and use of precise measurements, it is a matter of regret that the chapter on this subject should have been jettisoned instead of some of the pages dealing with the more elementary electrical facts of general knowledge.

It is thought that, even in a general treatise, the "wave antenna" for reception and the "multiple-tuned antenna" for transmission are worthy of more explanation, and that in dealing with the question of elimination of atmospherics a book on modern practice should have given prominence to the advantages of directional reception in increasing the signal/noise ratio.

These remarks, however, merely emphasise the difficulty of the task. Opinion must necessarily differ as to the relative importance of the items omitted and included. Generally speaking, the book is a splendid compendium of knowledge in regard to the subject of radio engineering; it is well written, is illustrated with an adequate number of clear diagrams and can be recommended as a general treatise and book of reference to those who wish to study the subject.

R.V.H.

"Electric Rectifiers and Valves." By A. Guntherschulze. Translated and revised by Norman A. de Brune. Published by Chapman & Hall, Ltd. Price 15/- net.

The publication by Messrs. Chapman & Hall of a second treatise on rectification within a year naturally invites a comparison between the two books.* It is probably sufficient to say that Mr. Jolley's book treats the subject from the engineering standpoint whilst the book under review deals with it more briefly from the physical standpoint.

The subject matter is presented in a thoroughly readable manner, although the author is rather fond of making references to particular types of rectifier in chapters which are applicable to several types. The book is divided into Physical and Technical Sections, the latter including a brief mathematical survey of rectifying circuits.

Any book on rectification published in this country should contain more than a passing reference to thermionic rectifiers as these are now being used in large numbers and are of general interest. In his introduction, the author refers to the fact that "this book is primarily concerned with rectifiers for currents bigger than those encountered in high frequency work." This may be so, but thermionic rectifiers are frequently used for powers far exceeding those for which mechanical, glow, discharge and electrolytic rectifiers are used, although these last types occupy quite a large portion of the book. The irony of this failure to do justice to the thermionic rectifier is completed by the reference (by the translator) in the last chapter to the Moullin thermionic voltmeter.

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* *"Alternating Current Rectification," L. B. W. Jolley. Reviewed in P.O.E.E. Journal, Vol. 20, No. 1.*

As a reference book on the physics of rectifiers, particularly of the mercury vapour type, this book will be welcomed, but an engineer seeking information on thermionic rectifiers will be disappointed.

"A Classified Guide to the Literature relating to the Engineering and Mechanical Industries." F. and E. Stoneham, Ltd., at the Librarian's Room, London, E.C.

A list of books published between August, 1926, and September, 1927, for the Annual Conference of the Library Association, Edinburgh, 1927.

IMPORTANT NOTICE.

The Board of Editors has decided to reduce the price of the Journal, beginning with the April number, to one shilling and threepence per copy. This arrangement will bring the purchaser of single copies into line with the annual subscriber who has been paying the round sum of five shillings per annum. Although no relief is being given to the annual subscriber, our readers will realise that another step has been taken in the return to pre-war prices, and the Board hopes that the growing circulation will continue apace, as therein lies the hope of a further reduction in price.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Bartholomew, S. C.	Executive Engineer, E.-in-C.O.	Acting Assistant Staff Engineer, E.-in-C.O.	26-10-27
Gravill, W. E.	Assistant Engineer, S. Mid. District.	Executive Engineer, London District.	23-10-27
Neate, E. P.	Assistant Engineer, London District.	Executive Engineer, London District.	To be fixed later.
Parker, T. T.	Repeater Officer, Class II., E. District.	Repeater Officer, Class I., E. District.	10-9-27
Mylius, W. A. J.	Repeater Officer, Class II., S.W. District.	Repeater Officer, Class I., S.W. District.	8-11-27
Furneaux, E. G.	Repeater Officer, Class II., E. District.	Repeater Officer, Class I., E. District.	19-10-27
Wood, J.	Inspector, Northern District.	Chief Inspector. Northern District.	30-10-27
Gawthorne, G. J.	Inspector, London District.	Chief Inspector, London District.	26-10-27
Deakin, R. E.	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	2-1-27
Colston, A. S.	Inspector, Scot. W. District.	Chief Inspector, N. Ireland District.	To be fixed later.
Morvan, A. R.	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	9-10-27
Clothier, W.	Skilled Workman, Class I., Northern District.	Inspector, Northern District.	17-7-27
Tomkinson, G.	Skilled Workman, Class I., N. Wales District.	Inspector, N. Wales District.	21-5-27

DEATHS.

Name.	District.	Grade.	Date.
McCall, D.	London.	Inspector.	30-9-27
Sanders, A. E.	N. Midland.	,,	27-6-27

RETIREMENTS.

Name.	District.	Grade.	Date.
Eldridge, E. J.	S. Western.	Superintending Engineer.	30-9-27
Trezise, J. M. G.	Met. Power.	Superintending Engineer.	31-12-27
Hunt, J. A.	London.	Executive Engineer.	30-9-27
Cardrey, A. G.	London.	Executive Engineer.	30-11-27
Latimer, F. D.	S. Eastern.	Assistant Engineer.	
Sorrell, J. E. A.	Eastern.	Repeater Officer, Class I.	18-10-27
Kemplay, R.	S. Western.	Repeater Officer, Class I.	7-11-27
Farrar, S.	Eastern.	Repeater Officer, Class I.	9-9-27
Ashbee, A. W.	S. Western.	Chief Inspector.	24-11-27
Jenkins, W. J.	S. Eastern.	Inspector.	28-8-27
Bull, C. E.	London.	Inspector.	17-9-27
Dolman, R. A.	N. Wales.	Inspector.	19-11-27
Deeny, H.	N. Ireland.	Inspector.	22-11-27
Linder, W.	S. Midland.	Inspector.	15-11-27
Hann, F.	Northern.	Inspector.	15-11-27

REVERSION.

Name.	From.	To.	
Green, W.	Chief Inspector, S.E. District.	Inspector, East District.	At own request.
Read, H. W.	Chief Inspector, S.W. District.	Inspector, S.W. District.	

APPOINTMENTS.

Name.	From.	To.	
Ackerman, H. M. W.	Inspector, London District.	Probationary Assistant Engineer, London District.	Limited Competition.
Potts, E.	Inspector, London District.	Probationary Assistant Engineer, London District.	
Hibberd, W. A.	Inspector, E.-in-C.O.	Probationary Assistant Engineer, E.-in-C.O.	
Luxton, W. G.	Inspector, E.-in-C.O.	Probationary Assistant Engineer, E.-in-C.O.	

CLERICAL ESTABLISHMENT.

PROMOTION

Name.	Grade.	Promoted to	Date.
Paddon, R. C.	Clerical Officer, London.	Higher Clerical Officer, London.	20-9-27
French, J. J.	Clerical Officer, London.	Acting Higher Clerical Officer, London.	29-9-27

BOARD OF EDITORS.

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All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 19 are available, and may be obtained from the local agents for 1*s*. 6*d*. and 3*d*. respectively. Subscribers can have their copies of Vol. 20 bound, with index included, at a cost of 3*s*. by sending the JOURNALS to the local agents. Orders for bindings, Vols. 1—19, should indicate whether the original binding with black lettering, or the later pattern in gold, is required. Covers with gold lettering will be the only type stocked from Vol. 20 onwards.

The price of the JOURNAL is 1*s*. 6*d*. (1*s*. 9*d*. post free) per copy, or 6*s*. per annum, post free. All back numbers 2*s*. each.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

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G.P.O., Alder House, E.C.1.

CENTRAL LIBRARY.

The following books have been added to the Central Library. Applications for the loan of same should be addressed to the Librarian, Institution of P.O. Electrical Engineers, Alder House, E.C.1.

LIST II.

No.	*Title.*	*Author.*
843	Essai sur l'Electricité des Corps...	Abbé Nollet.
844	The Post Office	Sir Evelyn Murray.
845	Elements of Telephone Transmission	H. H. Hamson.
846	New Electricity Act	W. S. Kennedy.
847	Elementary Electrical Engineering	A. E. Clayton and H. J. Shelley.
848	Up-to-date Motor Road Transport for Commercial Purposes ...	J. Phillimore.
849	Automatic Telephony	C. W. Wilman.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

BOOTH-BAUDOT AWARD.

The Council wishes to call attention to the "Booth-Baudot Award" of £5 which is now offered annually for the best improvement in Telegraph, Telephone or Wireless Apparatus or Systems. The award for the year 1927 is governed by the following conditions:—

1. The Award will be restricted to employees of the British Post Office.
2. Applications for the Award should be made between 1st January and 31st March, 1928, and such applications should refer to improvements made, or suggested, during the twelve months ending 31st December, 1927.

   Attention is drawn to the fact that recipients of Awards *via* the Post Office Awards Scheme in respect to any improvement in telegraph, telephone or wireless apparatus or systems are eligible to apply for the Booth-Baudot Award in respect thereto.
3. The Award may be withheld at the discretion of the Council of the Institution of Post Office Electrical Engineers if, after full consideration of the applications received, the adjudicators appointed by the Council are of the opinion that no award is warranted.
4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

R. V. HANSFORD,
Secretary.

December, 1927.